



Bass Lake
Aquatic Vegetation Management Plan
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Executive Summary

Aquatic Control was contracted by the Bass Lake Property Owners Association to complete aquatic vegetation sampling in order to develop a lakewide, long-term integrated aquatic vegetation management plan. Funding for development of this plan was obtained from the Bass Lake Property Owners Association and the Indiana Department of Natural Resources-Division of Soil Conservation as part of the Lake and River Enhancement fund (LARE). This plan was also created as a prerequisite to eligibility for LARE program funding to control exotic or nuisance species.

Aquatic vegetation is an important component of lakes in Indiana; however, as a result of many factors this vegetation can develop to a nuisance level. Nuisance aquatic vegetation, as used in this paper, describes plant growth that negatively impacts the present uses of the lake including fishing, boating, swimming, aesthetic, and lakefront property values. The primary nuisance species within Bass Lake is the exotic plant Eurasian watermilfoil (*Myriophyllum spicatum*). The negative impact of this species on native aquatic vegetation, fish populations, water quality, and other factors is well documented and will be discussed in further detail. In Bass Lake, Eurasian watermilfoil has negatively impacted boating, fishing, and swimming. It is also believed that this species has negatively impacted native vegetation. The primary goal of the Bass Lake Property Owner's Association is to reduce the impact of Eurasian watermilfoil on Bass Lake by more aggressively managing this nuisance exotic species while preserving and enhancing the native plant community. The primary recommendation for plant control within Bass Lake includes the use of triclopyr herbicide to selectively control Eurasian watermilfoil throughout the lake. This treatment in combination with aquatic plantings and increased idle zone areas should promote the recovery of native vegetation.

Acknowledgements

Funding for the vegetation sampling and preparation of an aquatic vegetation management plan was provided by the Indiana Department of Natural Resources – Division of Soil Conservation and the Bass Lake Property Owner’s Association (BLPOA). Aquatic Control Inc. completed the field work, data processing, and map generation. Identification and verification of some plant specimens were provided by Dr. Robin Scribailo of Purdue University North Central. Special thanks are given to IDNR biologists Bob Robertson and Cecil Rich for their review of this report. Special thanks are due for Joe and Cindy Carey of the Bass Lake Property Owners Association for their help in initiating and completing this project. Author of this report is Nathan Long of Aquatic Control. The author would like to acknowledge the valuable input from David Isaacs, Brian Isaacs, Joey Leach, Matt Johnson and Richard Radziwiecki of Aquatic Control for their field assistance, map generation, review, and editing of this report.

Table of Contents

Introduction..... 1

Watershed and Water Body Characteristics..... 1

Fisheries Review.....3

Present Waterbody Uses.....4

Aquatic Plant Community.....5

Plant Management History..... 15

Aquatic Plant Management Alternatives..... 16

Action Plan.....21

Education..... 23

References.....25

List of Figures

Figure 1. Bathymetric Map of Bass Lake.....	2
Figure 2. Lake Usage Map.....	5
Figure 3. Treatment and Sampling Areas.....	7
Figure 4. Tier I Plant Beds.....	8
Figure 5. Sampling Rake.....	10
Figure 6. Tier II Sampling Points.....	11
Figure 7. Aquatic vegetation distribution and abundance.....	12
Figure 8. Eurasian watermilfoil distribution and abundance.....	13
Figure 9. Chara distribution and abundance.....	13
Figure 10. Curlyleaf pondweed distribution and abundance.....	14
Figure 11. Small pondweed distribution and abundance.....	14
Figure 12. Sago pondweed distribution and abundance.....	15

List of Tables

Table 1. Tier I survey results.....	8
Table 2. Vegetation abundance, density, and diversity metrics compared to Average.....	11
Table 3. Species collected during Tier II sampling.....	12
Table 4. Bass Lake treatment history.....	16
Table 5. Advantages and disadvantages of potential control methods.....	21
Table 6. Budget estimates for management options.....	23

List of Appendices

Appendix A. Macrophyte Species List 26
Appendix B. Maps..... 28
Appendix C. Tier II Data Sheets.....39

Introduction

Aquatic Control was contracted by the Bass Lake Property Owners Association to complete aquatic vegetation sampling in order to develop a lakewide, long-term integrated aquatic vegetation management plan. Funding for development of this plan was obtained from the Indiana Department of Natural Resources-Division of Soil Conservation as part of the Lake and River Enhancement fund (LARE). This plan was created following the recommendation from the 2002 diagnostic study and as a prerequisite to eligibility for LARE program funding to control exotic or nuisance species.

Eurasian watermilfoil is the primary nuisance exotic species in Bass Lake. This species was first documented in Bass Lake by Aquatic Control Inc. in 1984. At that time, Eurasian watermilfoil was topped out in up to a 600 acre area. The Bass Lake Property Owners Association applied 2,4-D herbicide in order to control this species. Intermittent treatments with 2,4-D herbicide have been completed over the last 20 years depending on their budget and the extent of infestation. The Bass Lake Property Owners Association contracted Aquatic Control Inc. to complete this plan in order to more accurately document the plant community within Bass Lake and obtain funding to more aggressively pursue Eurasian watermilfoil in an attempt to eliminate it from the lake and prevent its spread to other lakes in the area. Increased Eurasian watermilfoil control efforts will help the Association fulfill the following goals:

1. Develop or maintain a stable, diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality and is resistant to minor habitat disturbances and invasive species.
2. Direct efforts to preventing and/or controlling the negative impacts of aquatic invasive species.
3. Provide reasonable public recreational access while minimizing the negative impacts on plant, fish, and wildlife resources.

Watershed and Water Body Characteristics

A diagnostic study was completed on Bass Lake in 2002 by J.F. New & Associates and the Center for Geospatial Data Analysis. This study was performed with funding from the Indiana Department of Natural Resources-Division of Soil Conservation and the Bass Lake Property Owners Association, Inc. (BLPOA). The following information is a summary of the 2002 diagnostic study.

Bass Lake is a 1,400 acre natural lake located about five miles southeast of Knox, Indiana off U.S. 35 and State Road 10 in the southeast corner of Starke County. Bass Lake is a relatively shallow lake with an average depth of 6 and a maximum depth of 22 to 24 feet (Figure 1). The lake's small watershed encompasses approximately 3030 acres. Bass Lake itself covers almost half of the watershed (47%). Much of the remaining portion of the watershed is forested (21%) or utilized for residential (15%) or agricultural (9.5%) purposes. An analysis of hydric soils in the watershed suggests that approximately 23%

of the original wetland acreage exists today. Development of the shoreline for residential use is the primary cause of this loss. Fifty-seven acres of land in the watershed is mapped in a potentially highly erodible soil unit.

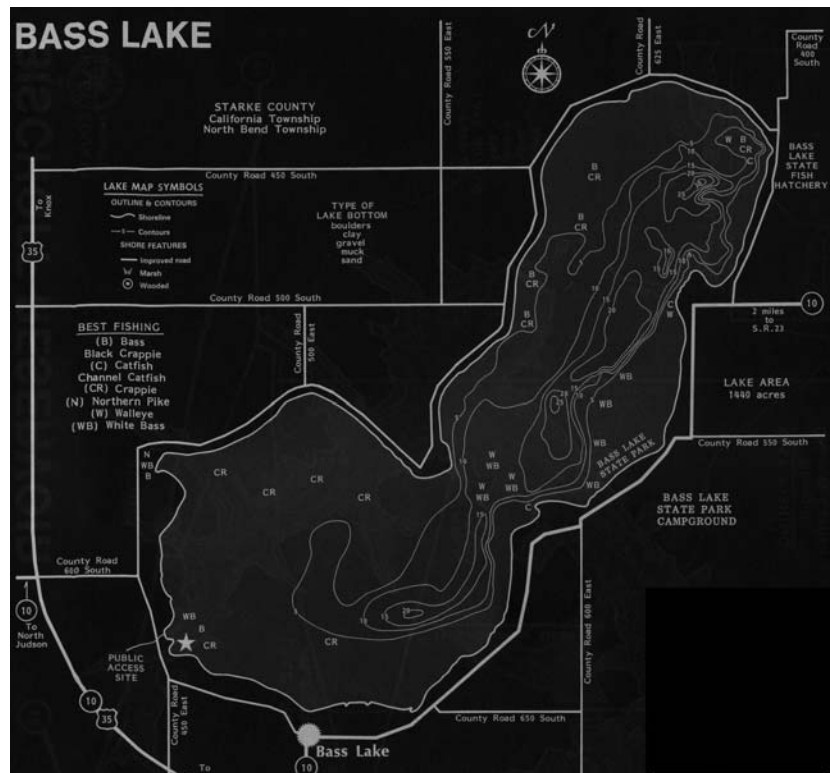


Figure 1. Bathymetric Map of Bass Lake (Bright Spot Maps, 1996)

Bass Lake is best classified as a eutrophic lake. In general, Bass Lake possesses poorer water quality than most other Indiana lakes. Bass Lake exhibits high total phosphorus and total organic nitrogen concentrations. Total phosphorus concentrations appear to be increasing with time. The lake's water clarity is poor with current and historical Secchi disk transparency measurements typically ranging from 1 to 4 feet. Phosphorus modeling indicates that 76% of the phosphorus in the lake originates from internal sources. Water balance modeling revealed that 47% of the lake's inflow comes from groundwater seepage and 30% of the lake's inflow is from precipitation. The Bass Lake Conservancy District's pumping operation makes up much of the remaining inflow. Very little of the lake's inflow comes from surface water drainage. Based on an evaluation of the geology in the area surrounding the lake, the clay layer separating the upper groundwater aquifer from the lower groundwater aquifer appears to be discontinuous. The connectivity of the two aquifers may have implications for any long-term operations.

The diagnostic study recommended the following actions: 1. Implement the groundwater monitoring system to evaluate the extent of connection between the upper and lower groundwater aquifers near Bass Lake; 2. Develop a recreational use management plan; 3. Conduct a feasibility study to determine the success of an alum treatment; 4. Consider adding alum dosing structure to the pump outfall; 5. Develop aquatic macrophyte

management plan; and 6. Implement homeowner action items (Geolitto & Olyphant, 2002).

Improvement of the watershed and reduction in phosphorus levels will not control nuisance vegetation. Typically, as watersheds are improved, water clarity will increase. This in turn will increase light penetration and allow for vegetation to grow in deeper water. Submersed vegetation obtains the majority of necessary nutrients from the sediment. Sediment in this area contains sufficient nutrients for plant growth. Based upon Aquatic Control's observations over the last thirty-nine years, we believe aquatic plants are not significantly limited by available phosphorus present in the water column. Bachmann, Hoyer, and Canfield, from the Department of Fisheries and Aquatic Sciences at the University of Florida recently conducted a study comparing the amount of available nutrients to plant growth. They sampled aquatic plant in 319 lakes between 1983 and 1999 and found no significant correlation between nutrients in lake water and the abundance of aquatic plants.

Fisheries

Included in the 2002 diagnostic study was a fishery review. This review covered fish survey reports as far back as 1900. More recent fish surveys were completed in 1972, 1974, 1979, 1980-1992, 1996, and 2001. Creel surveys were completed in 1992, 1996, and 2000. The review found that channel catfish (*Ictalurus punctatus*) were the primary component of the fish community in Bass Lake fisheries surveys. They dominated the IDNR's catch in 1972, 1974, 1982, 1984, and 1991. Robertson (1979) indicates that Bass Lake supported one of the best channel catfish fisheries in the state of Indiana. Black crappie (*Pomoxis nigromaculatus*) and white crappie (*Pomoxis annularis*) were also an important component of IDNR fisheries surveys. Crappie dominated the catch in 1979, 1985, and 1987 surveys. White bass (*Morone chrysops*) were a major species collected by the IDNR biologists in 1972, 1974, 1979, and 1982. White bass were absent from the 1983 survey. However, their numbers increased in surveys conducted after 1983. With exception of the 1983 and 1984 surveys, the percentage of walleye (*Stizostedion vitreum*) collected by the IDNR has remained between two and six percent of each survey sample. In general gizzard shad (*Dorosoma cepedianum*) numbers were lowered in the late 1980's and early 1990's compared to the population numbers observed in the 1970's and early 1980's. The quillback carpsucker (*carpiodes cyprinus*) population has fluctuated over the survey years.

In contrast to many other northern Indiana lakes, Bass Lake is almost devoid of bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*) according to the fisheries surveys. Competition for food and spawning territory with species such as white bass, crappie, walleye, and northern pike (*Esox lucius*) may be limiting bluegill and largemouth bass populations. Lack of aquatic vegetation, leading to insufficient spawning habitat, could also be contributing to low capture rates.

The IDNR has heavily managed Bass Lake for walleye. The management includes annual stocking. The IDNR has primarily stocked walleye fry, however, in 1982, biologists released walleye fingerlings as well. In general, fry survival, as measured by fall nighttime electrofishing surveys, has been excellent (Giolitto & Olyphant, 2002). Bass Lake is currently a popular fishing location for angler pursuing crappie and walleye.

Eurasian watermilfoil can also have negative impacts on fish populations. Dr. Mike Maceina of Auburn University found that dense stands of Eurasian watermilfoil on Lake Guntersville proved to be detrimental to bass reproduction due to the survival of too many small bass. This led to below normal growth rates for largemouth bass and lower survival to age 1. Maceina found higher age 1 bass density in areas that contained no plants versus dense Eurasian watermilfoil stands (Maceina, 2001). Bluegill growth rates can also be affected by dense stands of Eurasian watermilfoil. It is well known by fisheries biologists that overabundant dense plant cover gives bluegill an increased ability to avoid predation and increases the survival of small young fish, which can lead to stunted growth.

Present Water Body Uses

Approximately 600 homes line the shore of Bass Lake. The majority of the residents have docks and/or swimming areas in front of their residences. During the summer months, many of the residents enjoy fishing and swimming near their homes. The Bass Lake State Park Campground is located on the eastern shore of Bass Lake. A public beach is located within the state park. Bass Lake is a very popular water skiing and pleasure boating lake. A public access site is located in the southwest corner of the Lake (Figure 2).

Bass Lake can become very crowded with boats during the summer months. The resident boat count revealed that over 900 motorized boats are moored at the lake (Giolitto and Olyphant, 2002). The 2002 diagnostic study, as well as several fisheries reports, point to the possibility that this heavy boat traffic may be partly responsible for the degraded water quality. The wave action generated by boat traffic will not allow submersed vegetation to become established. Wave action can also stir up sediments creating the turbid water conditions that are common at Bass Lake.

A residential survey was conducted by J.F. New & Associates. The results of this survey were summarized in the 2002 diagnostic study. The survey found that local residents, as well as out-of town users, regularly engaged in a variety of activities on Bass Lake. The survey showed a potential for conflicts in which one use impairs or prohibits another use. Lake residents listed swimming and boating as their two favorite activities on Bass Lake. These two activities can obviously come into conflict. Fishing was listed as the third favorite activity. Fishing and power boating can also come into conflict. These conflicts led to the recommendation that a Recreational Use Management Plan be created (Giolitto & Olyphant, 2002).

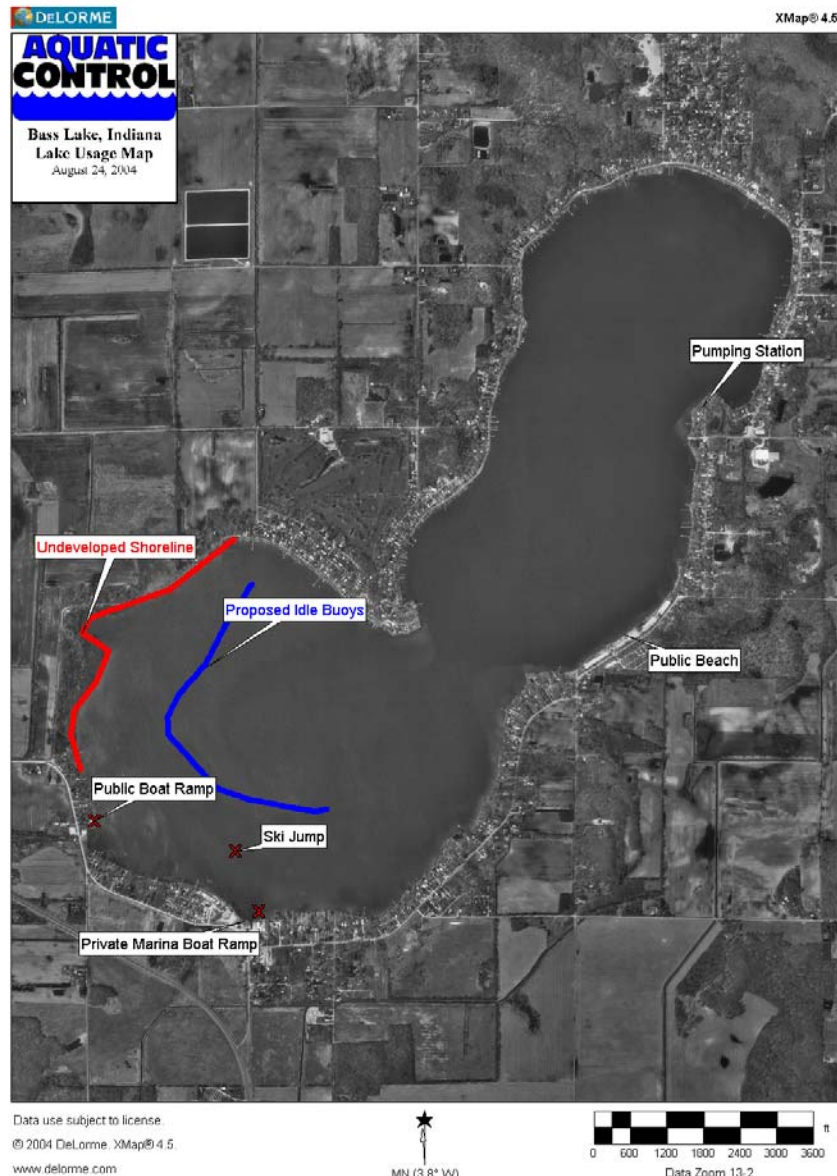


Figure 2. Lake Usage Map (not to scale see appendix)

Aquatic Plant Community

There is limited data available concerning past aquatic plant surveys on Bass Lake. The most recent surveys have been completed by IDNR fisheries biologists prior to fisheries surveys. These surveys point to a lack of native vegetation within Bass Lake. In 2001, a plant survey was conducted prior to the development of the diagnostic study. The survey indicated that with the exception of an occasional chara (*Chara spp.*) mat, only three small pockets of floating or submerged vegetation were present. Each of these areas was a cove protected on at least two sides from wave and wind energy. Dominant species

were spatterdock (*Nuphar variegatum*) and white water lily (*Nymphaea odorata*). The survey found a limited amount of curlyleaf pondweed (*Potamogeton crispus*) and Eurasian watermilfoil growing in deeper areas along the lakeward edge of the plant beds. The diagnostic study theorized that the reasons for the lack of vegetation were high turbidity, boat traffic, wind action, and recent treatment activities (Giolitto & Olyphant, 2002). The authors of this report agree with the first three theories, but the use of herbicides is not limiting native vegetation. Prior to 2001, 2,4-D herbicide was the only chemical used in Bass Lake. This herbicide is selective to dicot species, meaning it will not affect pondweeds or naiads, which comprise a large percentage of Indiana's native vegetation. The only species being limited by 2,4-D herbicide applications is Eurasian watermilfoil and possibly coontail (*Ceratophyllum demersum*).

Aquatic Control Inc. has completed visual plant surveys prior to several herbicide applications. Eurasian watermilfoil has been the primary nuisance species documented. A 600-acre bed of Eurasian watermilfoil was present in 1984. This milfoil bed was located in the southern portion of the lake. In 2004, Aquatic Control was contacted concerning regrowth of Eurasian watermilfoil in the southern section of the lake. Aquatic Control conducted a visual survey in June and roughly mapped a bed of 115 acres of Eurasian watermilfoil, which had reached or was near the surface.

On June 28, 2004, Aquatic Control conducted sampling prior to treatment in one area of Bass Lake (Figure 3). Eurasian watermilfoil was the dominant species (90% relative abundance) followed by chara (9%), and curlyleaf pondweed (1%).



Figure 3. Bass Lake, June 28, 2004 treatment and sampling areas (not to scale see appendix)

Tier I and Tier II sampling was completed on Bass Lake on August 28, 2004. Ideally two Tier II surveys should be completed in a season in order to document changes in plant community characteristics that occur over the course of the spring through late summer seasons, but due to time limitations a single survey was completed in 2004.

Tier I Survey

The Tier I survey was developed to serve as a qualitative surveying mechanism for aquatic plants. The Tier I survey is based upon the procedure manual developed by Shuler & Hoffmann, 2002. This survey will serve to meet the following objectives:

1. to provide a distribution map of the aquatic plant species within a waterbody
2. to document gross changes in the extent of a particular plant bed or the relative abundance of a species within a waterbody (IDNR, 2004)

The Tier I survey revealed seven distinct plant beds within Bass Lake totaling 800 acres. (Table 1 & Figure 4). Plant bed 1 was the largest plant bed at 780 acres. This plant bed encompasses the majority of the littoral zone. Typically, there would be several distinct plant beds in an area of this size, however there was no significant difference concerning aquatic vegetation within this large area. The substrate of plant bed 1 was sand and high

in organics. A total of 6 species were observed within the plant bed. Chara was the dominant plant species (2-20% abundance rating), followed by Eurasian watermilfoil, curlyleaf pondweed, small pondweed (*Potamogeton pusillus*), white water lily, and spatterdock. All of these species were present at less than 2% abundance. Eurasian watermilfoil historically has been the dominant species in this area based upon past visual observations. A herbicide treatment was conducted using Renovate herbicide in June of 2004. This treatment was very successful, so Eurasian watermilfoil was not present at past levels.

Table 1. Tier I Survey Results

Plant Bed I.D.	#1	#2	#3	#4	#5	#6	#7
Plant Bed Size (acres)	780.0	1.0	1.2	0.5	0.5	1.15	3.0
	Rating*	Rating*	Rating*	Rating*	Rating*	Rating*	Rating*
Eurasian Watermilfoil**	1	1	-	-	1	-	-
White Water Lily	1	2	2	2	1	3	1
Spatterdock	1	4	3	3	4	3	2
Chara	2	-	-	-	-	-	-
Small Pondweed	1	-	-	-	-	-	-
Curlyleaf Pondweed**	1	-	-	-	-	-	-
Watershield	-	-	-	-	-	-	4

*rating is scored from 1 to 4 with 1 being least dense and 4 being most dense

**exotic species



Figure 4. Tier I Plant Beds, Bass Lake, August 24, 2004 (not to scale see appendix)

Plant bed 2 encompassed a 1-acre area. The substrate of plant bed 2 was sand. A total of 3 species were observed within the plant bed. Spatterdock was the dominant species and comprised greater than 60% of the plant bed. White water lily ranked second in abundance and comprised 2-20% of the plant bed. Eurasian watermilfoil was also present at less than 2% abundance.

Plant bed 3 was determined to be 1.2 acres. The substrate of plant bed 3 was sand and high in organics. Only two species were observed within the plant bed. Spatterdock was the dominant species and comprised 21-60% of the plant bed. White water lily ranked second in abundance and comprised 2-20% of the plant bed.

Plant bed 4 was one of the smallest plant beds at 0.5 acres. The substrate of plant bed 4 was sand and high in organics. Only two species were observed within the plant bed. White water lily was the dominant species and comprised 21-60% of the plant bed. Spatterdock ranked second in abundance and comprised 2-20% of the plant bed.

Similar to plant bed 4, plant bed 5 was also 0.5 acres. The substrate of plant bed 5 was sand and high in organics. Three species were observed within the plant bed. Spatterdock was the dominant species and comprised greater than 60% of the plant bed. White water lily and Eurasian watermilfoil were present at less than 2% abundance.

Plant bed 6 was determined to be 1.15 acres. The substrate of plant bed 5 was sand and high in organics. Only two species were observed within the plant bed. Spatterdock and white water lily each were determined to be between 21-60% abundance.

Plant bed 7 was determined to be 3.0 acres. The substrate of plant bed 7 was sand and high in organics. Three species were observed within the plant bed. Watershield (*Brasenia schreberi*) was the dominant species and comprised greater than 60% of the plant bed. Spatterdock was determined to be between 2 and 20% abundance. White water lily was also present at less than 2% abundance.

Tier II Survey

Creation of the aquatic vegetation management plan also requires sampling to quantify the occurrence, distribution, and abundance aquatic vegetation. This type of survey will be referred to as the Tier II survey. This protocol is currently being used by the IDNR Division of Fish and Wildlife to provide a quantitative sampling mechanism for aquatic plant surveying. This protocol supplements the Tier I Reconnaissance Protocol for plant bed mapping. Together the protocols should serve to meet the following objectives:

1. to document the distribution and abundance of submersed and floating-leaved aquatic vegetation
2. to compare present distribution and abundance with past distribution and abundance within select areas (IDNR, 2004).

All of the data which was collected through the use of this protocol was recorded on standardized data sheets. The data collected was compared to data collected by district fisheries biologist Jed Pearson, which is presented in his 2004 paper "A Sampling

Method to Assess Occurrence, Abundance, and Distribution of Submersed Aquatic Plants in Indiana Lakes”. In this paper, Pearson used 21 northern Indiana lakes to calculate various aquatic plant abundance and diversity metrics. We used the same sampling procedure outlined in Pearson’s paper to calculate these same metrics for Bass Lake. The data collected will also be valuable for future comparison, which will document changes in the plant community following proposed management activities.

A pre-determined number of sample sites are randomly selected throughout the littoral zone. The number of sites is determined by the lake size. Once a site was reached the boat was slowed to a stop and the coordinates were recorded on a hand-held GPS unit and later downloaded into a mapping program. A depth measurement was taken by dropping a two-headed standard sampling rake that was attached to a rope marked off in 1-foot increments (Figure 5). An additional ten feet of rope was released and the boat was reversed at minimum operating speed for a distance of ten feet. Once the rake is retrieved the overall plant abundance on the rake is scored from 1-5 and then individual species are placed back on the rake and scored separately (the rake is marked off in 5 equal sections on the tines).

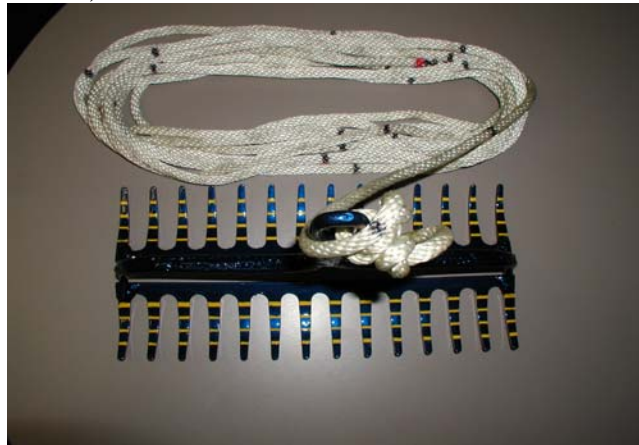


Figure 5. Sampling Rake

Tier II sampling took place August 24, 2004 immediately following the Tier I sampling. A total of 161 sample sites were randomly selected within the littoral zone of Bass Lake (Figure 6). A Secchi disk reading was taken prior to sampling and was found to be 1.5 feet. Plants were present to a maximum depth of 6-feet. The mean depth from which samples were taken was 3.42 feet. The mean rake density score for Bass Lake was 0.71. Species richness (average number of species per site) was 0.60 for all species and 0.27 for natives only. This was well below the average calculated from Pearson’s data. Site species diversity index was 0.53 for all species and 0.09 for native species only. Bass Lake had a rake diversity score 0.53 for all species and 0.05 for natives only (Table 2). Distribution and density of aquatic vegetation is illustrated in Figure 7. This sampling illustrates that bass lake has a low diversity and abundance of native vegetation compared to other natural lakes in Indiana. Steps need to be taken to improve this situation.



Figure 6. Tier II Sample Points (not to scale see appendix)

Table 2. Bass Lake vegetation abundance, density, and diversity metrics compared to average

	Bass Lake*	Average**
Percentage of sample sites with vegetation	44%	-
# of species collected	5	8
# of native species collected	3	7
Mean Rake Density	0.71	3.30
Rake Diversity (SDI)	0.53	0.62
Native Rake Diversity (SDI)	0.05	0.50
Species Richness (Avg # spec./site)	0.60	1.61
Native Species Richness	0.27	1.33
Site Species Diversity	0.53	0.66
Site Species native diversity	0.09	0.56

*standard deviation not included

**average calculated from Pearson Data.

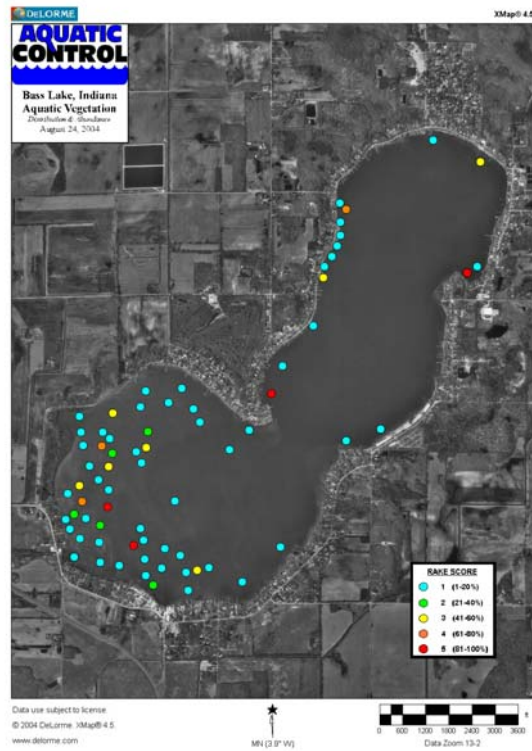


Figure 7. Aquatic vegetation distribution and abundance (not to scale see appendix)

A total of 5 species were collected of which 3 of the species were natives (Table 3). Eurasian watermilfoil and curlyleaf pondweed were the exotic species collected. Eurasian watermilfoil was present in the highest percentage of sample sites (32.3%) (Figure 8), followed by Chara (25.5%) (Figure 9) and curlyleaf pondweed (1.2%) (Figure 10). Small pondweed and sago pondweed (*Potamogeton pectinatus*) were found at a single sample site (Figure 11 & 12).

Table 3. Species Collected During Tier II Sampling.

Common Name	Scientific Name	Frequency of Occurrence	Relative Density*	Dominance Index**
Eurasian Watermilfoil	<i>Myriophyllum spicatum</i>	32.3	0.42	8.3
Chara	<i>Chara spp.</i>	25.5	0.43	8.7
Curlyleaf Pondweed	<i>Potamogeton crispus</i>	1.2	0.01	0.2
Small Pondweed	<i>Potamogeton pusillus</i>	0.6	0.01	0.1
Sago Pondweed	<i>Potamogeton pectinatus</i>	0.6	0.01	0.1

*Mean rake scores at all sites

**Percent of maximum abundance

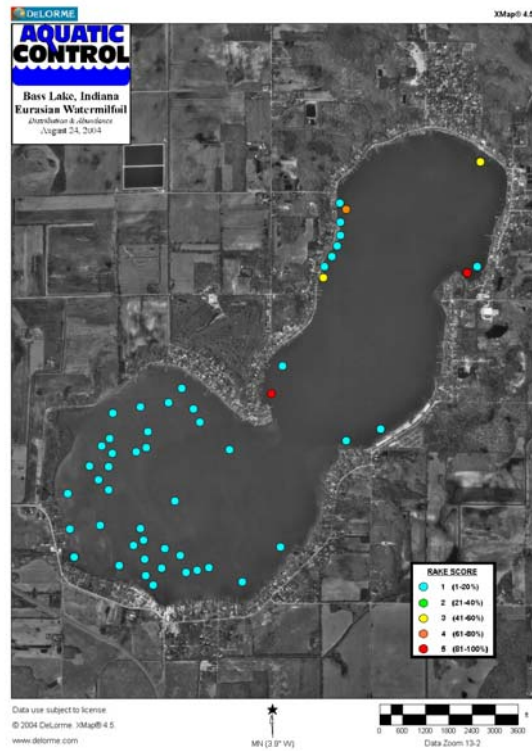


Figure 8. Eurasian watermilfoil distribution and abundance (not to scale see appendix)

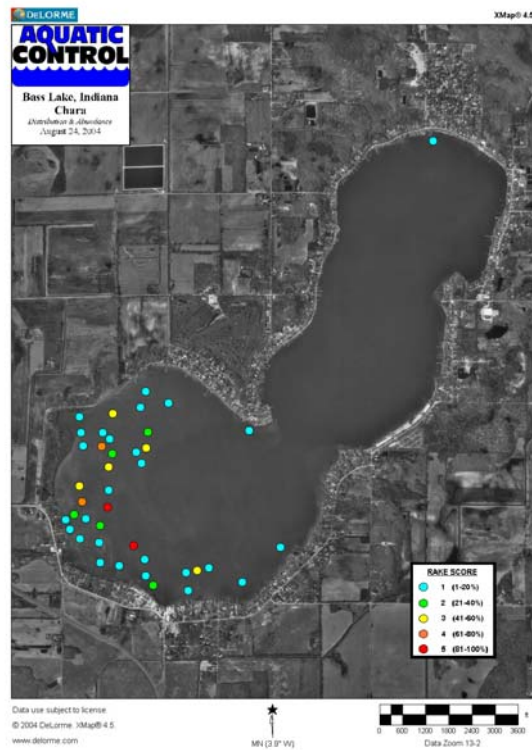


Figure 9. Chara distribution and abundance (not to scale see appendix)

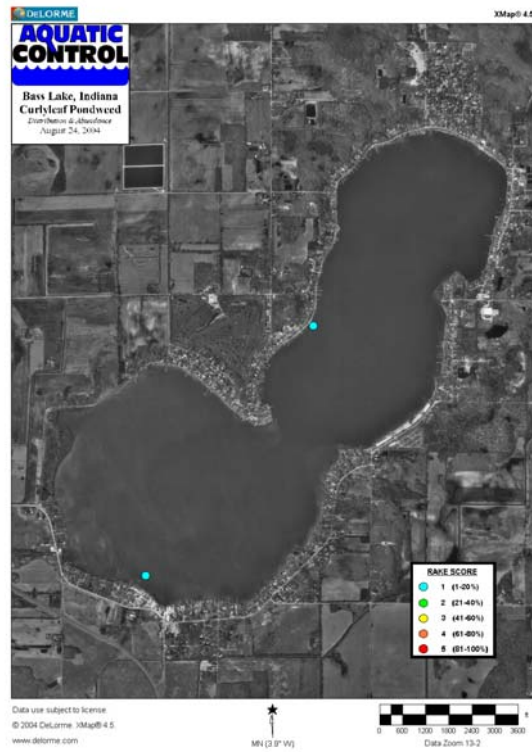


Figure 10. Curlyleaf pondweed distribution and abundance (not to scale see appendix)

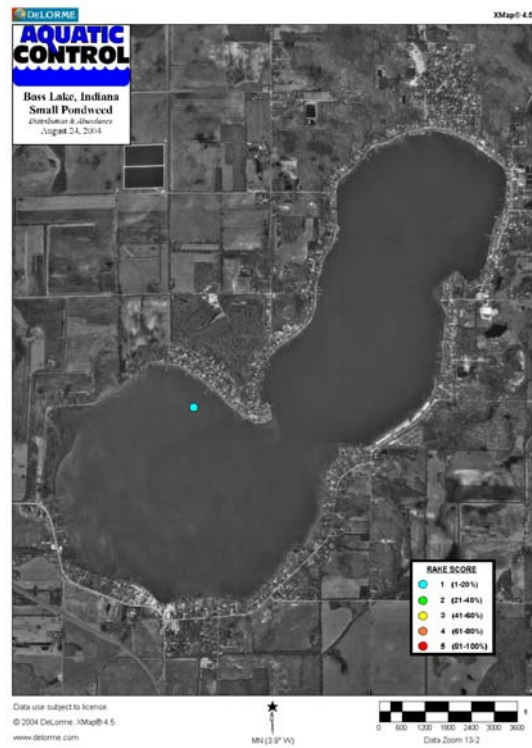


Figure 11. Small pondweed distribution and abundance (not to scale see appendix)

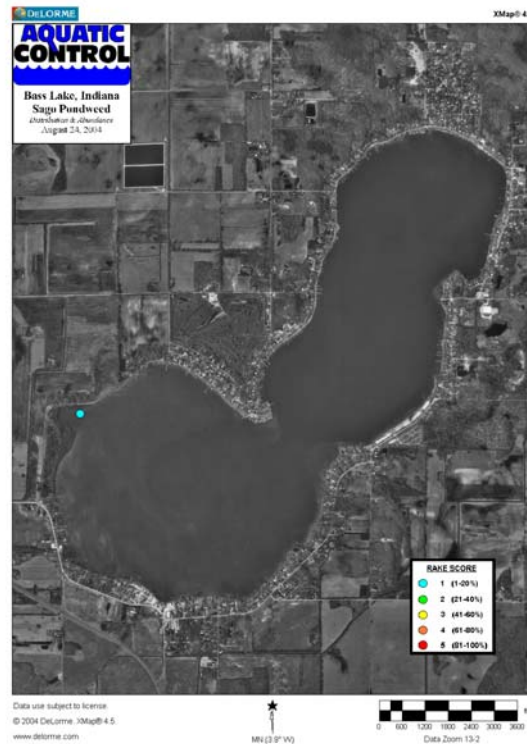


Figure 12. Sago pondweed distribution and abundance (not to scale see appendix)

Plant Management History

Aquatic Control Inc. was initially contacted by representatives of the Bass Lake Property Owner's Association in August, 1984, regarding a severe aquatic vegetation problem. Inspection of the lake verified that the problem species was Eurasian watermilfoil. It appeared that this species was the only nuisance species in Bass Lake. The major infestation was found to be in the relatively shallow south basin of Bass Lake. Estimates of coverage ranged from 400-600 acres at that time. The milfoil beds were "topped out" over a large portion of the off-shore area in the south bay. This heavy growth essentially prevented recreational use of the majority of this bay. Boating activity in the area resulted in extensive fragmentation of milfoil plants providing massive amounts of viable cuttings available for starting new colonies. These colonies were noted in shallow water areas throughout Bass Lake wherever suitable substrate was available for attachment of these rooting fragments.

Various aquatic plant management strategies were considered and discussed. These discussions resulted in a decision to initiate a program of control utilizing aquatic herbicides. Contact herbicides were ruled out because they would produce only short-term knockdown of the nuisance plants with no control of the root portion of the plant, allowing rapid regrowth. Aquatic Control recommended two systemic herbicides for consideration; granular 2,4-D and fluridone. Both of these herbicides had demonstrated selectivity for Eurasian watermilfoil.

In 1985, the association elected to complete the treatment using their own resources and using 2,4-D herbicide. Results were reported to be very good with a major reduction in coverage reported in 1986. In 1990, Aquatic Control Inc. completed treatment using 2,4-D herbicide to 120-acres of milfoil in the south basin under a permit from IDNR. Treatments between 100 and 150-acres of Eurasian watermilfoil with 2,4-D herbicide were completed off and on until 2004 (Table 4). In 2004, no treatment was planned, but Aquatic control was contacted in early June and asked to complete a treatment as soon as possible. Eurasian watermilfoil had returned at near the same level as 2003 prior to treatment. A new herbicide name triclopyr (trade name Renovate) had just been approved the previous year. This herbicide is a systemic herbicide, which is selective towards milfoil. A 115-acre area was treated with this new herbicide and results of this treatment were excellent.

Table 4. Bass Lake Treatment History

Year	Treatment Activity
1985	Bass Lake P.O.A. treated Eurasian watermilfoil area in south basin with 2,4-D herbicide
1986	No treatment
1987	No treatment
1988	No treatment
1989	No treatment
1990	Aquatic Control Inc. treated a 120 acre of milfoil in south basin with 2,4-D herbicide
1991	Aquatic Control Inc. treated 100 acre area of milfoil in south basin with 2,4-D herbicide
1992	No treatment
1993	Aquatic Control Inc. treated 105 acres of milfoil in south basin with 2,4-D herbicide
1994	No treatment
1995	No treatment
1996	No treatment
1997	No treatment
1998	Aquatic Control Inc. treated 140 acres of milfoil with 2,4-D herbicide
1999	No treatment
2000	Aquatic Control Inc. treated 150 acres of milfoil with 2,4-D herbicide
2001	Not treatment
2002	No treatment
2003	Aquatic Control Inc. treated 150 acres of milfoil with 2,4-D herbicide
2004	Aquatic Control Inc. treated 115 acres of milfoil in south basin with triclopyr herbicide

Aquatic Plant Management Alternatives

The main nuisance aquatic vegetation within Bass Lake is the exotic species Eurasian watermilfoil (*Myriophyllum spicatum* L.). It is believed that Eurasian watermilfoil was first introduced from Eurasia or North Africa to an area near Maryland around 1942, possibly through the aquarium trade. Some reports suggest that this species may have

been introduced into North America as early as the late 1800's through shipping ballast (Ditomaso & Healy, 2003). This species has now spread throughout the majority of North America and is the primary nuisance submersed aquatic species in Indiana. Once established, growth and physiological characteristics of Eurasian watermilfoil enable it to form a surface canopy and develop into immense stands of weedy vegetation, out competing most submersed species and displacing the native plant community (Madsen et al., 1988).

It is obvious that steps need to be taken in order to prevent Eurasian watermilfoil from returning to pre-treatment levels. The Bass Lake Property Owners Association has been able to raise enough funds to treat Eurasian watermilfoil when it reached nuisance levels. However, an annual program should be developed in order to prevent this species from reaching these levels. Cost of such a program is beyond the budget of the Bass Lake Property Owners Association.

In order to develop a scientifically sound and effective action plan for control of Eurasian watermilfoil, all aquatic management alternatives need to be considered. The alternatives that will be discussed include: no action; environmental manipulation; chemical, mechanical, or biological control methods; and any combination of these methods.

A number of different techniques have been successfully used to control Eurasian watermilfoil (Table 5 at the end of this section summarizes the control methods). These techniques vary in terms of their efficacy, rapidity, and selectivity, as well as the thoroughness and longevity of control they are capable of achieving. Each technique has advantages and disadvantages, depending on the circumstances. Selectivity is a particularly important characteristic of control techniques. Nearly all aquatic plant control techniques are at least somewhat selective, in that they affect some plant species more than others. Even techniques such as harvesting that have little selectivity within the areas to which they are applied can be used selectively, by choosing only certain areas in which to apply them. Selectivity can also occur after the fact, as when a technique controls all plants equally but some grow back more rapidly. One facet of selecting an appropriate aquatic plant control technique is matching the selectivity of the control technique with the goals of aquatic plant management. When controlling Eurasian watermilfoil, for example, it is typically desirable to use techniques that control Eurasian watermilfoil with minimal impact on most native species (Smith, 2002).

No Action

What if no aquatic plant management activity took place on Bass Lake? This was the case prior to 1984 and Eurasian watermilfoil was present in dense monoculture stands covering almost one-third of the lake, so it is feasible to believe this would be the case if no action was taken. Eurasian watermilfoil would most likely return to pre-1984 levels within 3-4 years if no management activity was initiated.

Environment manipulation

Environmental manipulation for Bass Lake would include water level draw-down. Successful use of water draw-down for controlling Eurasian watermilfoil typically

requires drawing down water levels sufficiently to expose the entire Eurasian watermilfoil population. This technique can be moderately effective if the drawdown exposes the entire Eurasian watermilfoil population to freezing and thawing, however drawdown can result in the expansion of Eurasian watermilfoil into deeper water. Drawdown can also have negative affects on native plant species.

Mechanical

Mechanical control includes cutting, dredging, or tilling the bottom sediments to eliminate aquatic plant growth. The main advantage to mechanical control is the immediate removal of the plant growth from control areas and the removal of organic matter and nutrients.

One of the most common mechanical control techniques used on larger lakes in Indiana is mechanical harvesting. Mechanical harvesting uses machines which cut plant stems and, in most cases, pick up the cut fragments for disposal. This type of mechanical control has little selectivity. Where a mix of Eurasian watermilfoil and native species exists, harvesting favors the plant species that grow back most rapidly following harvesting. In most cases, Eurasian watermilfoil recovers from harvesting much more rapidly than native plants. Thus, repeated harvesting hastens the replacement of native species by Eurasian watermilfoil and often leads to dense monocultures of Eurasian watermilfoil in frequently harvested areas. Harvesting also stirs up bottom sediments thus reducing water clarity, killing fish and many invertebrates, and hastening the spread of Eurasian watermilfoil via fragmentation. For these reasons, harvesting is not recommended as a primary Eurasian watermilfoil control method.

Harvesting can also be used as a control technique by individual homeowner's around dock areas. There are lake rakes and other tools, which can be purchased for this activity. A lake frontage property owner can maintain a 625 square foot area (25ft. x 25ft) without a permit.

Biological

Biological controls reduce aquatic vegetation using other organisms that consume aquatic plants or cause them to become diseased (Smith, 2002). The main biological controls for Eurasian watermilfoil used in Indiana are the white amur (grass carp) and the milfoil weevil.

The white amur or grass carp *Ctenopharyngodon idella* is a herbivorous fish imported from Asia. Triploid grass carp, the sterile genetic derivative of the diploid grass carp, are legal for sale in Indiana. Grass carp tend to produce all or nothing aquatic plant control. It is very difficult to achieve a stocking rate sufficient to selectively control nuisance species without eliminating all submersed vegetation. They are not particularly appropriate for Eurasian watermilfoil control because Eurasian watermilfoil is low on their feeding preference list; thus, they eat most native plants before consuming Eurasian watermilfoil (Smith, 2002). Grass carp are also difficult to remove from a lake once they have been stocked. Grass carp are not recommended for Eurasian watermilfoil control.

The milfoil weevil, *Euhrychiopsis lecontei*, is a native North American insect that consumes Eurasian and Northern watermilfoil. The weevil was discovered following a natural decline of Eurasian watermilfoil in Brownington Pond, Vermont (Creed and Sheldon, 1993), and has apparently caused declines in several other water bodies. Weevil larvae burrow in the stem of Eurasian watermilfoil and consume the vascular tissue thus interrupting the flow of sugars and other materials between the upper and lower parts of the plant. Holes where the larvae burrow into and out of the stem allow disease organisms a foothold in the plants and allow gases to escape from the stem, causing the plants to lose buoyancy and sink (Creed et al. 1992).

Concerns about the use of the weevil as a biological control agent relate to whether introductions of the milfoil weevil will reliably produce reductions in Eurasian watermilfoil and whether the resulting reductions will be sufficient to satisfy users of the lake (Smith, 2002). Following our research, no conclusive data concerning the role of weevils in reducing Eurasian watermilfoil populations has been made available. In 2003, Scribailo & Alix conducted a weevil release study on three Indiana lakes and had no conclusive evidence supporting the use of weevils in reducing milfoil populations. Weevils may reduce milfoil populations in some lakes, but predicting which lakes and how much, if any, control will be achieved has not been documented.

Chemical Control

Chemical control uses chemical herbicides to reduce or eliminate aquatic plant growth. The main advantage of using herbicides is their overall effectiveness. The public's main concern over herbicide use is safety. This should not be a concern due to the extensive testing which is required prior to a herbicide being approved for use in the aquatic environment. These tests ensure that the herbicides are low in toxicity to human and animal life and they are not overly persistent or bioaccumulated in fish or other organisms. Another concern over the use of herbicides is the potential nutrient release that can take place following a treatment. This can be avoided by early applications before targeted vegetation reaches its maximum biomass.

There are two different types of aquatic herbicides; systemic and contact. Systemic herbicides are translocated throughout the plants and thereby kill the entire plants. Fluridone (trade name Sonar & Avast!), 2,4-D (trade name Navigate, Aqua-Kleen, & DMA4 IVM), and triclopyr (trade name Renovate) are systemic herbicides that can effectively control Eurasian watermilfoil.

Based upon the author's experience and personal communication with a vast array of North American aquatic plant managers, whole-lake fluridone applications are by far the most effective means of controlling Eurasian watermilfoil. Successful fluridone treatments yield a dramatic reduction in the abundance of Eurasian watermilfoil, often reducing it to the point that Eurasian watermilfoil plants are difficult to detect following treatment (Smith, 2002). An advantage to using fluridone over most contact herbicides is its selectivity. Most strains of Eurasian watermilfoil have a lower tolerance to fluridone than the majority of native species, so if the proper rates are applied Eurasian watermilfoil can be controlled with little harm to the majority of native species.

Triclopyr is a systemic herbicide that has recently been approved for use in aquatics. Triclopyr typically is used for treating isolated milfoil beds as opposed to whole lake treatments. This herbicide is very selective to Eurasian watermilfoil. A study was completed on the effects of triclopyr which found Eurasian watermilfoil biomass was reduced by 99% in treated areas at 4 weeks post-treatment, remained low one year later, and was still at acceptable levels of control at two years post-treatment. Non-target native plant biomass increased 500-1000% by one year post-treatment, and remained significantly higher in the cove plot at two years post-treatment. Native species diversity doubled following herbicide treatment, and the restoration of the community delayed the re-establishment and dominance of Eurasian watermilfoil for three growing season (Getsinger et. al., 1997) Triclopyr is a good alternative to fluridone when Eurasian watermilfoil is not abundant throughout an entire water body. This herbicide was used in Bass Lake in 2004 with excellent results.

Applied properly, 2,4-D can also yield major reductions in the abundance of Eurasian watermilfoil, but long-term reductions are more difficult to achieve using 2,4-D than using whole-lake fluridone applications. Treatments must be even and dose rates accurate. Under the best circumstances, some areas will probably need to be treated repeatedly before the Eurasian watermilfoil in them is controlled. Also, the difficulty of finding and treating areas of sparse Eurasian watermilfoil makes it likely that Eurasian watermilfoil will be reestablished from plants surviving in these areas (Smith, 2002). This formulation should be used much like triclopyr, but the same results may not occur. Unlike Triclopyr, 2,4-D can impact the native species coontail. This herbicide has been used on Bass Lake since 1985 and the results have been good in the treatment areas.

Contact herbicides can also be effective for controlling submersed vegetation in the short term. The three primary contact herbicides used for control of submersed vegetation are diquat (trade name Reward), endothal (trade name Aquathol), and copper based formulations (trade names Komeen, Nautique, and Clearigate).

Historically, a drawback to the use of contact herbicides has been the lack of selectivity exhibited by these herbicides. However, a study recently completed by Skogerboe and Getsinger outlines how endothal can be used for control of the exotic species curlyleaf pondweed and Eurasian watermilfoil with little effect on the majority of native species. They found early season treatments with endothal effectively controlled Eurasian watermilfoil and curlyleaf pondweed at several application rates with no regrowth eight weeks after treatment. Sago pondweed, eel grass, and Illinois pondweed biomass were also significantly reduced following the endothal application, but regrowth was observed at eight weeks post-treatment. Coontail and elodea showed no effects from endothal at three of the lower application rates. Spatterdock, pickerelweed, cattail, and smartweed were not injured at any of the application rates (Skogerboe & Getsinger 2002). This type of treatment strategy could be applied to lakes that have large areas of both curlyleaf pondweed and Eurasian watermilfoil. Endothal could also be effective the year after whole lake fluridone treatments where curlyleaf pondweed typically returns the following season.

Diquat and many of the copper formulations are effective fast acting contact herbicides. These formulations are typically used when control of all submersed vegetation is desired. Aquatic Control uses these herbicides for control of nuisance vegetation around docks and near-shore high-use areas. These herbicides are not selective and plants can often times recover in 4-8 weeks after treatment.

Table 5. Advantages and disadvantages of potential control methods.

Control Method	Advantages	Disadvantages	Conclusion
No Action	No cost, less controversy	No plant control, degradation of fish habitat, difficult boating, and spread of exotic plant species.	Something should be initiated to prevent spread of milfoil and reduce nuisance conditions.
Environmental Manipulation (drawdown)	Low cost, compaction of flocculent sediments, may get control of some nuisance species, and less controversial.	Unpredictable plant control, exposes desirable plants and animals to freezing and thawing, dependent on good freeze, could impede recreation, dependent on spring rains to raise water level, and not feasible for Bass Lake..	Not feasible for Bass Lake due to difficulty in manipulation of water level.
Mechanical (cutting, dredging, or tilling)	Low cost, less controversy, can target areas of desired control, removes organics.	Possibility of spreading exotic vegetation, labor intensive, damage to fish and other aquatic organisms, and harvesting can promote increased milfoil growth.	Not good option due to potential spread of exotics. Could possibly be used on small-scale initial infestation or post-treatment.
Biological Control (milfoil weevil)	No chemical needed, naturally occurring native species, no use restrictions following application, selective for Eurasian watermilfoil, and known to cause fatal damage to plant	Studies have been inconclusive on the effectiveness and cost is relatively high compared to most other control methods.	No proof that this method is effective. Too large of an investment for unproven method.
Biological Control (Grass Carp)	No chemical needed, no use restrictions following application, and proven to consume aquatic vegetation.	Prefers many of the native species over exotic species, non-native fish species, tend to move downstream, once they are introduced they are nearly impossible to remove.	Not a good option due to inability to remove once stocked and preference for native vegetation.
Chemical Control	Proven safe and effective technique, can be selective, relatively easy application, and fast results.	Higher cost than most techniques, public concern over chemicals, build-up of dead plant material following application, and lake use restrictions	Proven to be effective & minimal use restrictions very effective Eurasian watermilfoil control

Action Plan

Vegetation management activities have taken place on Bass Lake since at least 1985. This activity included the treatment of Eurasian watermilfoil with 2,4-D herbicide once

the plants reached nuisance levels. In 2004, triclopyr herbicide was successfully used in place of 2,4-D herbicide.

The 2004 sampling discovered Eurasian watermilfoil at 32.3% of sites. The density of Eurasian watermilfoil exceeded a rake score of 1 at only five sites (a single plant fragment receives a score of 1). The low density of Eurasian watermilfoil, especially in the south basin, is likely due to the 2004 treatment. The majority of Eurasian watermilfoil sampled in the treatment area was dead and beginning to break down.

The sampling also revealed a lack of native vegetation in Bass Lake. This may be due to a variety of factors; high turbidity, competition with Eurasian watermilfoil, or high wave action from heavy boat traffic. There were beds of beneficial emergent vegetation scattered around the shoreline, but these were few and isolated. Steps should be taken to improve the abundance and diversity of native species and protect the current native plant beds. This may include increasing idle zone areas, aquatic plantings, and a more aggressive Eurasian watermilfoil treatment program.

Current plant management activities focus on controlling milfoil after it reaches nuisance levels. The Bass Lake Property Owners Association has been in charge of determining when the species reaches nuisance levels. This strategy has worked to a point, but Eurasian watermilfoil continues to reinfest treatment areas within one to two years after treatment. The Bass Lake Conservancy District should take a more aggressive approach to prevent this reinfestation. This would allow control of Eurasian watermilfoil before it developed a large biomass thus reducing the amount of dead and decaying plant material following a treatment. A more aggressive approach may also help increase the establishment of native vegetation in treatment areas. A whole-lake fluridone treatment would be the best tool to more aggressively control this nuisance species. However, due to the lack of native vegetation, State fisheries biologists have expressed concern over eliminating all plant cover in the lake if even for a short period of time. It is our recommendation that the Association should pursue funding for an aggressive treatment program with using triclopyr herbicide.

Triclopyr Treatments

In 2004, a triclopyr treatment was completed on 115 acres of nuisance Eurasian watermilfoil beds. These beds were interfering with boating activity in the south basin. Only Eurasian watermilfoil areas that were considered to be nuisance were treated. Scattered patches of Eurasian watermilfoil were present throughout the lake but not treated. It is likely that these scattered patches will help re-infest the treatment areas within 1-2 years. The triclopyr treatment showed much better control of Eurasian watermilfoil than past 2,4-D treatments. However, this herbicide is more expensive and the treatment was limited to the densest areas of Eurasian watermilfoil. This herbicide should be applied to all areas where Eurasian watermilfoil occurs in order to prevent surviving plants from quickly reinfesting treatment areas. A maximum of 150 acres of Eurasian watermilfoil may require treatment next season. It is impossible to predict the exact amount and where this vegetation will occur. The treatment should only be made

after plant sampling takes place. Plant sampling will allow for creation of an accurate treatment map.

Additional Management Options

The 2004 sampling indicated a severe lack of native vegetation abundance and diversity. No matter which Eurasian watermilfoil control technique is implemented, steps need to be taken to increase the abundance and diversity of native vegetation. Currently there are small areas of rooted-floating vegetation widely scattered around Bass Lake (see Figure 4). These plant beds are beneficial for fish cover, nutrient filtering, and the overall health of Bass Lake. Steps should be taken to protect and increase the coverage of these plant beds. It is our belief that native vegetation is limited due to high-speed boat traffic in shallow areas and competition with Eurasian watermilfoil. This report focused on control of Eurasian watermilfoil, but there are additional actions that should be taken to improve native abundance and diversity. This may include increasing idle zones in sensitive shallow areas, planting of native vegetation, and education about the benefits of native vegetation.

Aquatic vegetation sampling should be a part of any action plan. This sampling should consist of a Tier I survey and a pair of Tier II surveys. These surveys should be completed in late May and July. These surveys will monitor the effects of potential herbicide treatments and determine if adjustments need to be made in the strategy. The data gathered from this sampling will be valuable for planning future management activities. Table 6 includes budget estimates for the above options.

Table 6. Budget estimate for management options

	2005	2006	2007	2008
Herbicide & Application Cost	\$60,000	\$20,000	15,000	\$10,000
Vegetation Sampling & Plan Update	\$3,000	\$3,000	3,000	\$3,000
Aquatic Vegetation Planting	-	-	\$10,000	\$10,000
Total:	\$63,000	\$23,000	28,000	\$23,000

Education

It is important that all lake users, lake residents, and other stakeholders participate and be informed about the lake management activities. A public meeting was conducted November 11, 2004 to obtain user input and discuss the findings of the 2004 vegetation sampling. A second meeting should also be scheduled to discuss the draft management plan. Each winter a meeting should take place to discuss necessary changes in the plan and to update lake users of changes and activities. Mailings documenting aquatic vegetation management activities, treatment restrictions, and management options should

be distributed to members of the association. Signs should be posted at all public and private ramps warning of the spread of exotic species. Additional information concerning aquatic vegetation management can be obtained at the following web sites:

www.mapms.org www.aquatics.org www.apms.org, www.aquaticcontrol.com
www.nalms.org.

References

- Applied Biochemists. 1998. Water weeds and algae, 5th edition. Applied Biochemists, J. C. Schmidt and J. R. Kannenberg, editors. Milwaukee, Wisconsin.
- Bright Spot Maps. 1996. Kosciusko-Marshall-Fulton-Elkhart-St. Joseph Counties, 74 Lake Maps Featuring Contours and Depths. Laporte, IN
- Chadde, S.W. 1998. A Great Lakes Wetland Flora. Pockteflora Press, Calumet Michigan.
- DiTomaso, J. M., and E.A. Healy. 2003. Aquatic and Riparian Weeds of the West. University of California Agriculture and Natural Resources. Oakland, CA.
- Fassett, N.C. 1968. A Manual of Aquatic Plants. The University of Wisconsin Press. Madison, WI.
- Getsinger, K.D., Turner, E.G., Madsen, J.D., and M.D. Netherland. 1997. Restoring Native Vegetation in a Eurasian Water Milfoil-Dominated Plant Community Using The Herbicide Triclopyr. Regulated Rivers: Research & Management, Vol. 13, 357-375.
- Giolitto, M., and G. Olyphant. 2002. Bass Lake Diagnostic Study Starke County, Indiana. J.F. New & Associates. Walkerton, Indiana & Center for Geospatial Data Analysis, Indiana University, Bloomington, Indiana.
- IDNR. 2004. Procedure Manual For Surveying Aquatic Vegetation: Tier I Reconnaissance Surveys. IN Department of Natural Resources, Division of Soil Conservation.
- IDNR. 2004. Procedure Manual For Surveying Aquatic Vegetation: Tier II Reconnaissance Surveys. IN Department of Natural Resources, Division of Soil Conservation.
- Maceina, M.J., Reeves, W.C., Wrenn, W.B., and D.R. Lowery. 1996. Relationships Between Largemouth Bass and Aquatic Plants in Guntersville Reservoir, Alabama. American Fisheries Society Symposium 16:382-395.
- Madsen, J.D., Sutherland, J.W., Bloomfield, J.A., Eichler, L.W., and C.W. Boylen, 1988. The decline of native vegetation under dense Eurasian watermilfoil canopies. Journal of Aquatic Plant Management., 29, 94-99.
- Pearson, J. 2004. A Sampling Method to Assess Occurrence, Abundance and Distribution of Submersed Aquatic Plants in Indiana Lakes. IN Department of Natural Resources. Division of Fish & Wildlife.

- Scribalio, R.W., and M.S. Alix. 2003. Final Report on the Weevil Release Study for Indiana Lakes. Department of Botany and Plant Pathology. Purdue University. West Lafayette, IN.
- Skogerboe, J.G., and K.D. Getsinger. 2002. Endothall species selectivity evaluation: northern latitude aquatic plant community. J. Aquatic Plant Management. 40: 1-5.
- Smith, C.S. 2002. Houghton Lake Management Feasibility Study. Prepared for the Houghton Lake Improvement Board. Remetrix LLC. Indianapolis, IN.
- Winterringer, G. S. and A.C. Lopinot. 1977. Aquatic Plants of Illinois. Department of Registration & Education, Illinois State Museum Division & Department of Conservation, Division of Fisheries. Springfield, IL.

Appendix A. Macrophyte List for Bass Lake

Common Name	Scientific Name	Tier I Survey	Tier II Survey
Chara	<i>Chara spp.</i>	X	X
Curlyleaf Pondweed	<i>Potamogeton crispus</i>	X	X
Eurasian Watermilfoil	<i>Myriophyllum spicatum</i>	X	X
Sago Pondweed	<i>Potamogeton pectinatus</i>	-	X
Small Pondweed	<i>Potamogeton pusillus</i>	X	X
Spatterdock	<i>Nuphar spp.</i>	X	-
Watershield	<i>Brasenia schreberi</i>	X	-
White Water Lily	<i>Nymphaea tuberosa</i>	X	-

Curlyleaf pondweed (*Potamogeton crispus*) is a submersed monocot with slightly clasping, rounded tip leaves. The flowers occur on dense cylindrical spikes and produces distinctive beaked fruit¹. Curly leaf is eaten by ducks, but may become a weed². This plant provides good food, shelter, and shade for fish and is important for early spawning fish like carp and goldfish².



Eurasian watermilfoil (*Myriophyllum spicatum*) is an exotic aquatic plant that has been known to crowd out native species of plants. This species spreads quickly because it can grow from very small plant fragments and survive in low light and nutrient conditions¹. This dicot has stems that typically grow to the water surface and branch out forming a canopy that shades other species of aquatic plants. Eurasian water-milfoil has characteristic red to pink flowering spikes that protrude from the water surface one to two inches high¹. The segmented leaves grow in whorls of three to four around the stem¹. This exotic plant is easily differentiated from its native relative, northern milfoil, by stem growth and the numbers of sections per leaf.



Spatterdock (*Nuphar spp.*) is an emergent dicot with broad, deeply lobed leaves emerging from the water¹. This plant has distinctive large yellow flowers emanating from spikes. Spatterdock produces seeds and rootstocks that are used by wildfowl, beaver, moose and porcupine². This plant attracts wildfowl and marsh birds and the bases of the petioles are eaten by muskrats². Spatterdock is a poor producer of food for fish, but provides good shade and shelter².



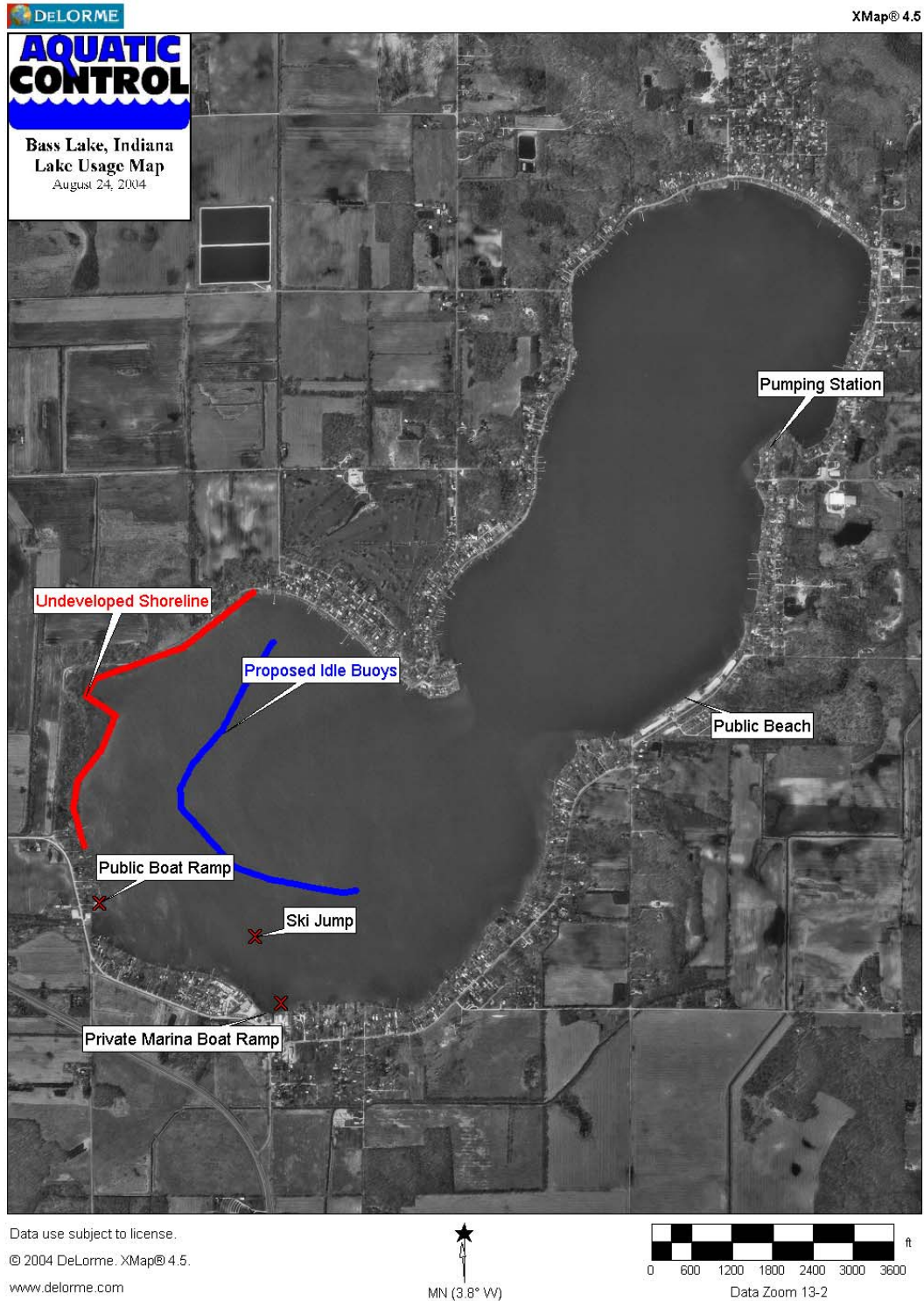
¹ Applied Biochemists, 1998. Water weeds and algae, 5th edition. Applied Biochemists, J. C. Schmidt and J. R. Kannenberg, editors. Milwaukee, Wisconsin.

² Chadde, Steve W. 1998. A Great Lakes Wetland Flora. Pockteflora Press, Calumet Michigan.

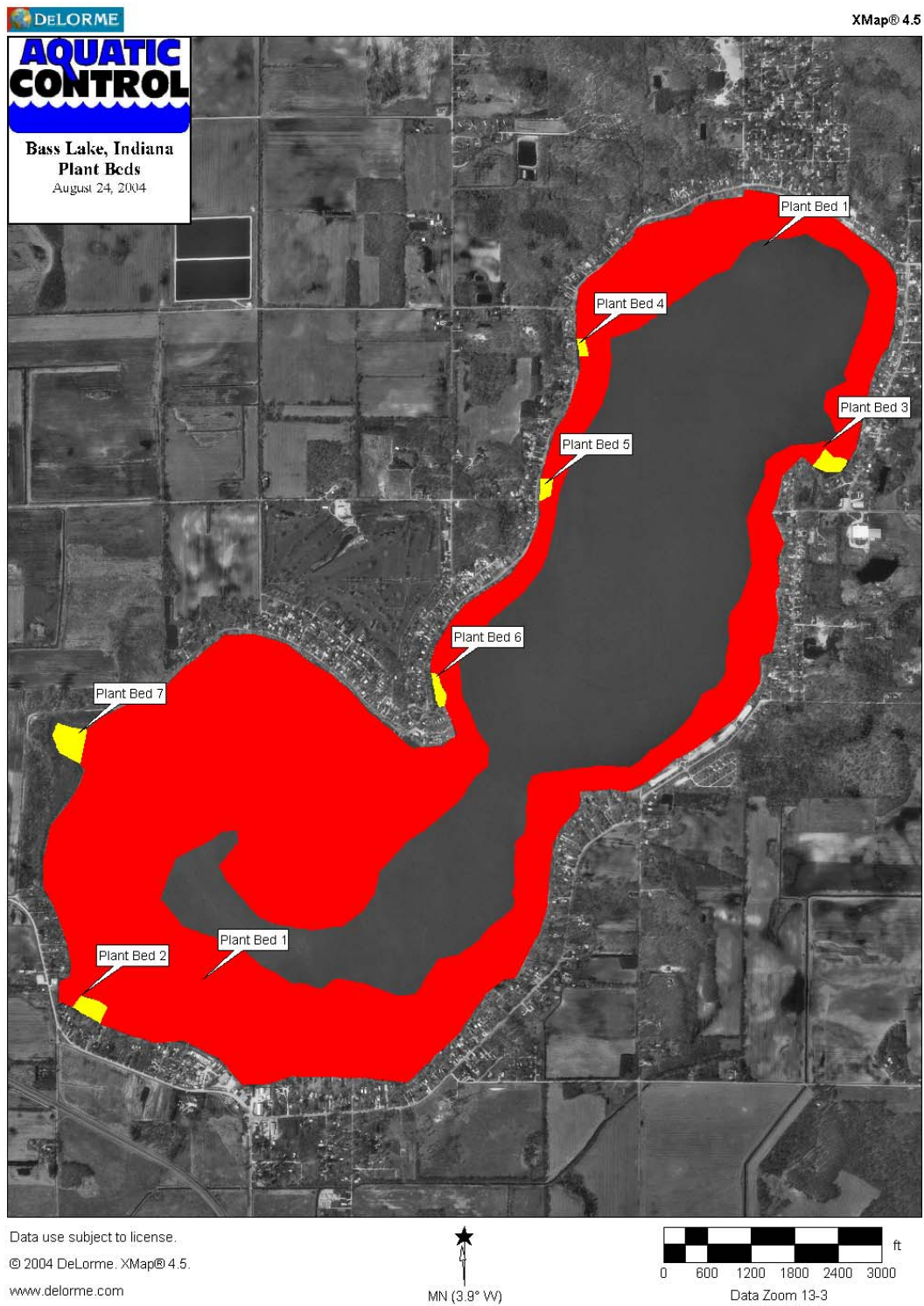
White water lily (*Nymphaea odorata*) is a floating attached dicot that grows from tubers and produces broad, deeply lobed floating leaves and white flowers¹. This plant produces seed that is fair food for wildfowl². The root stocks and petiole bases are eaten by muskrats and the “roots” are eaten by beaver, deer, moose, and porcupine². White water lilies can provide good habitat for fish, but can induce a negative value when too dense².



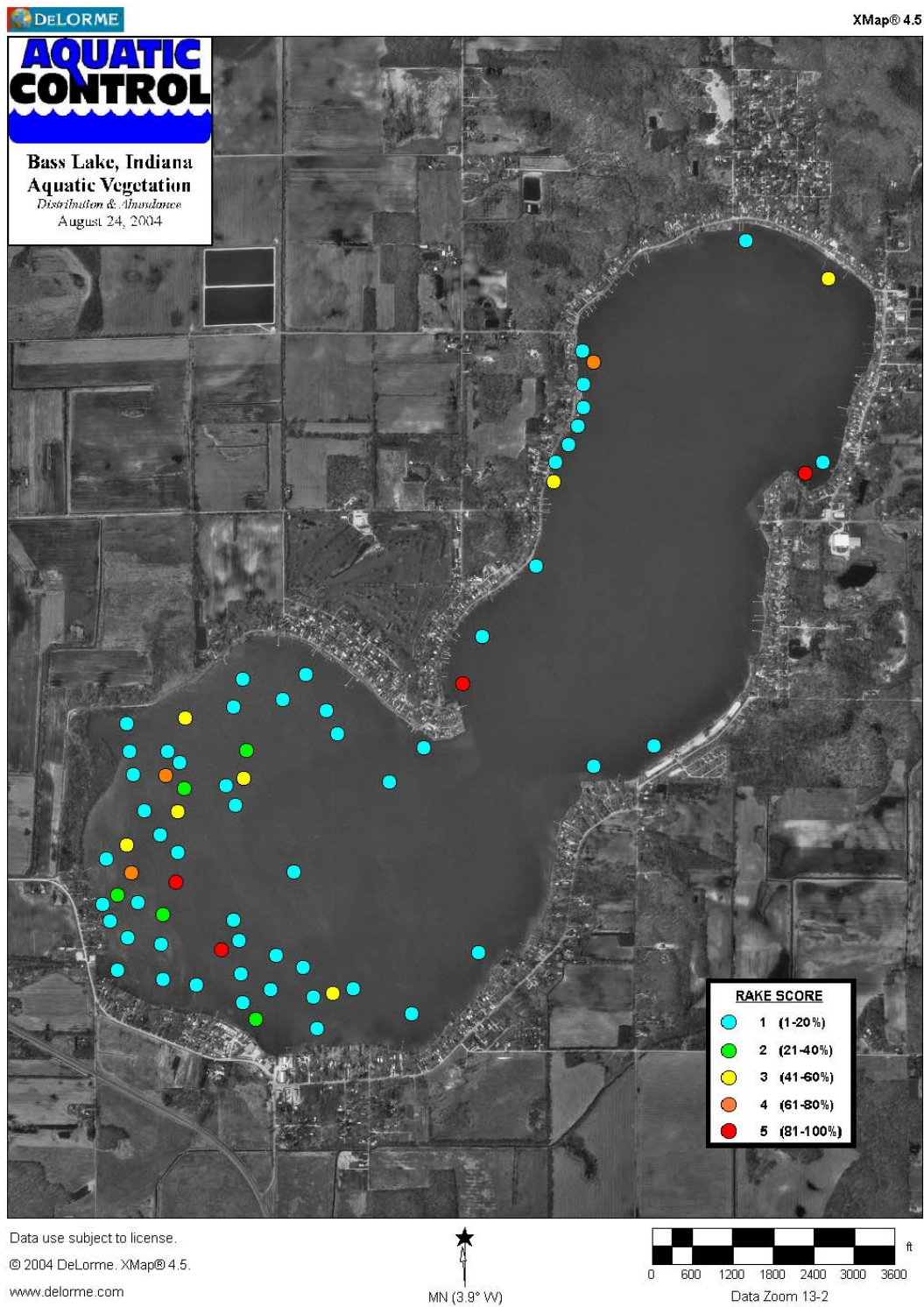
Appendix B. Maps

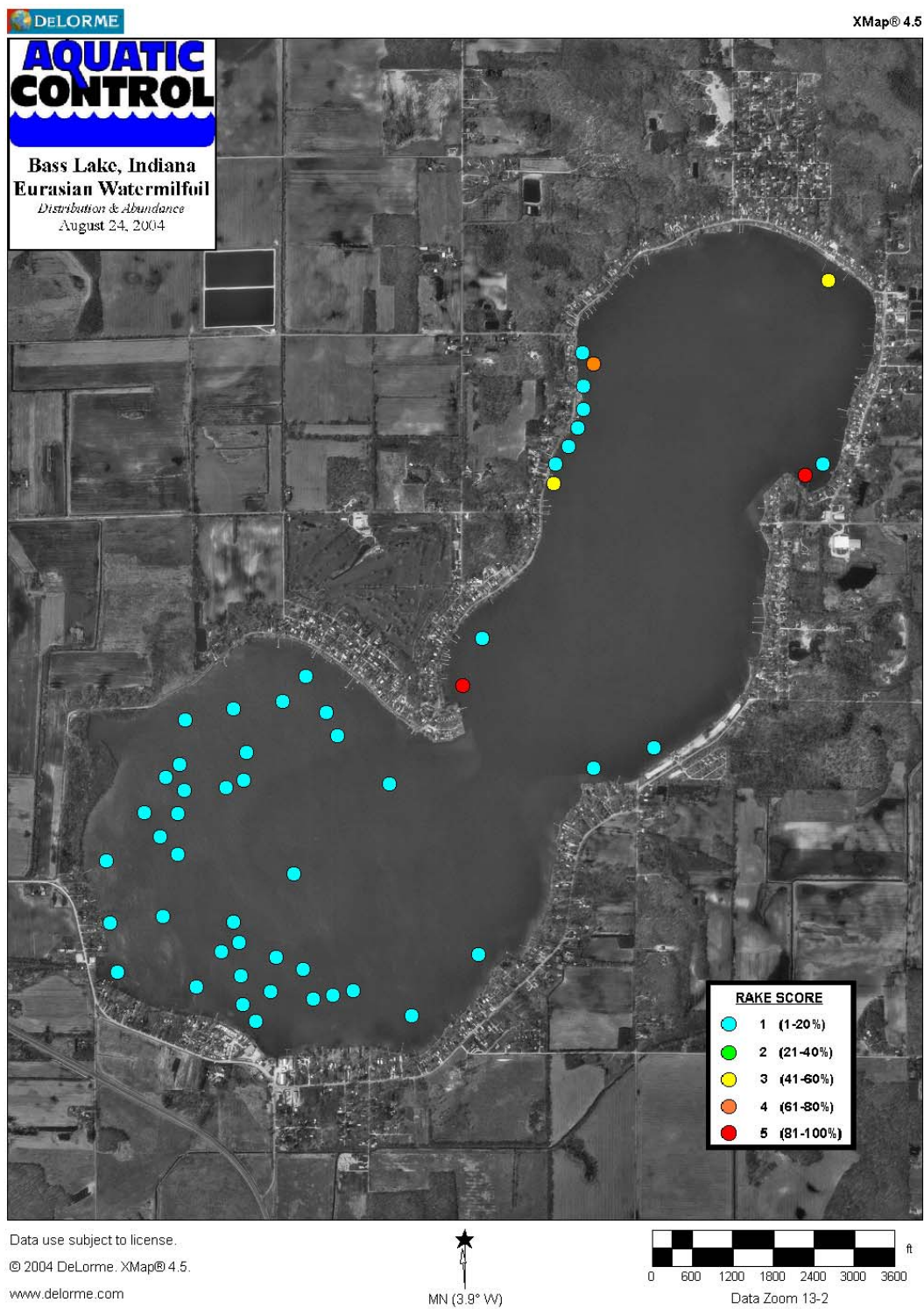


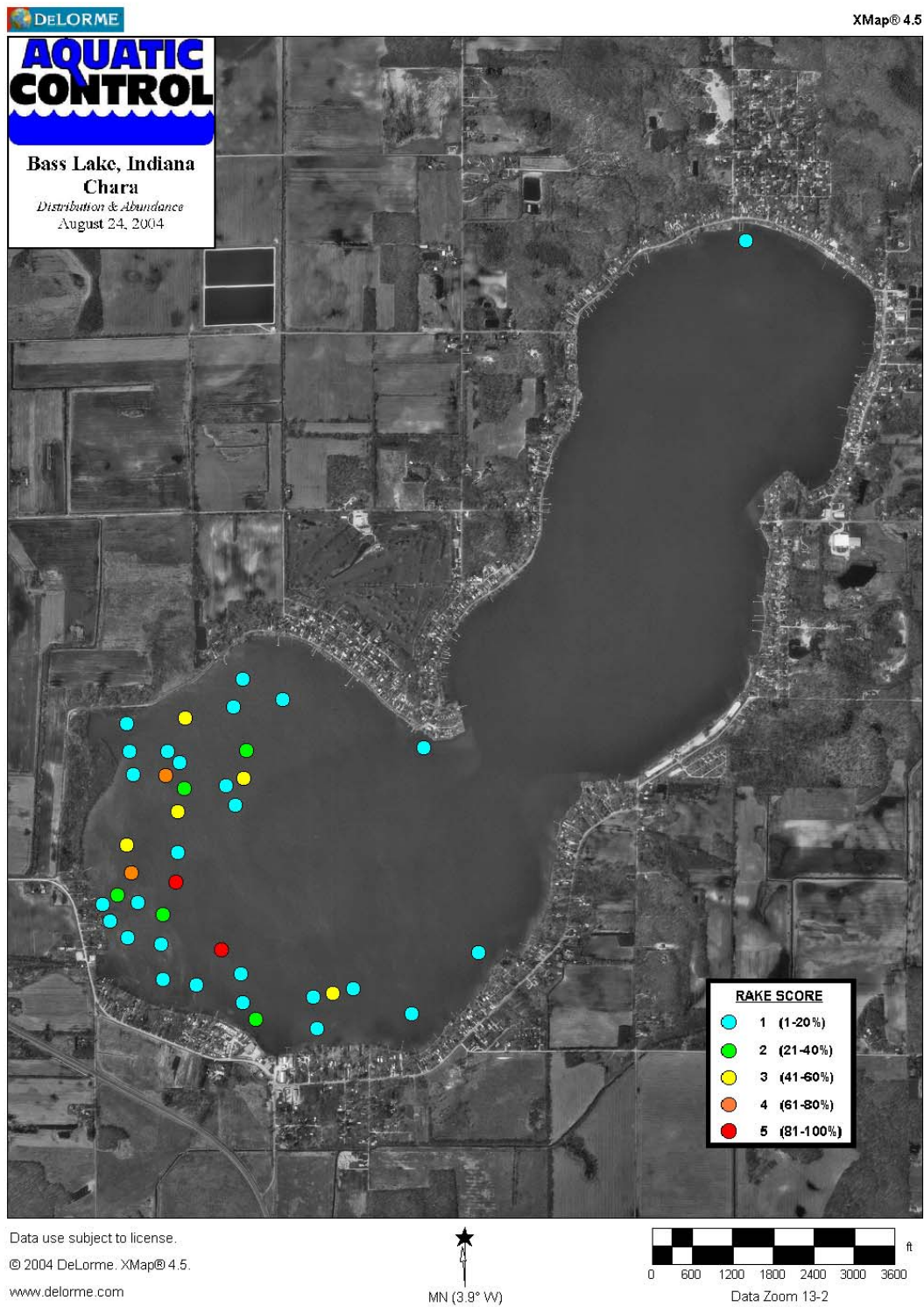


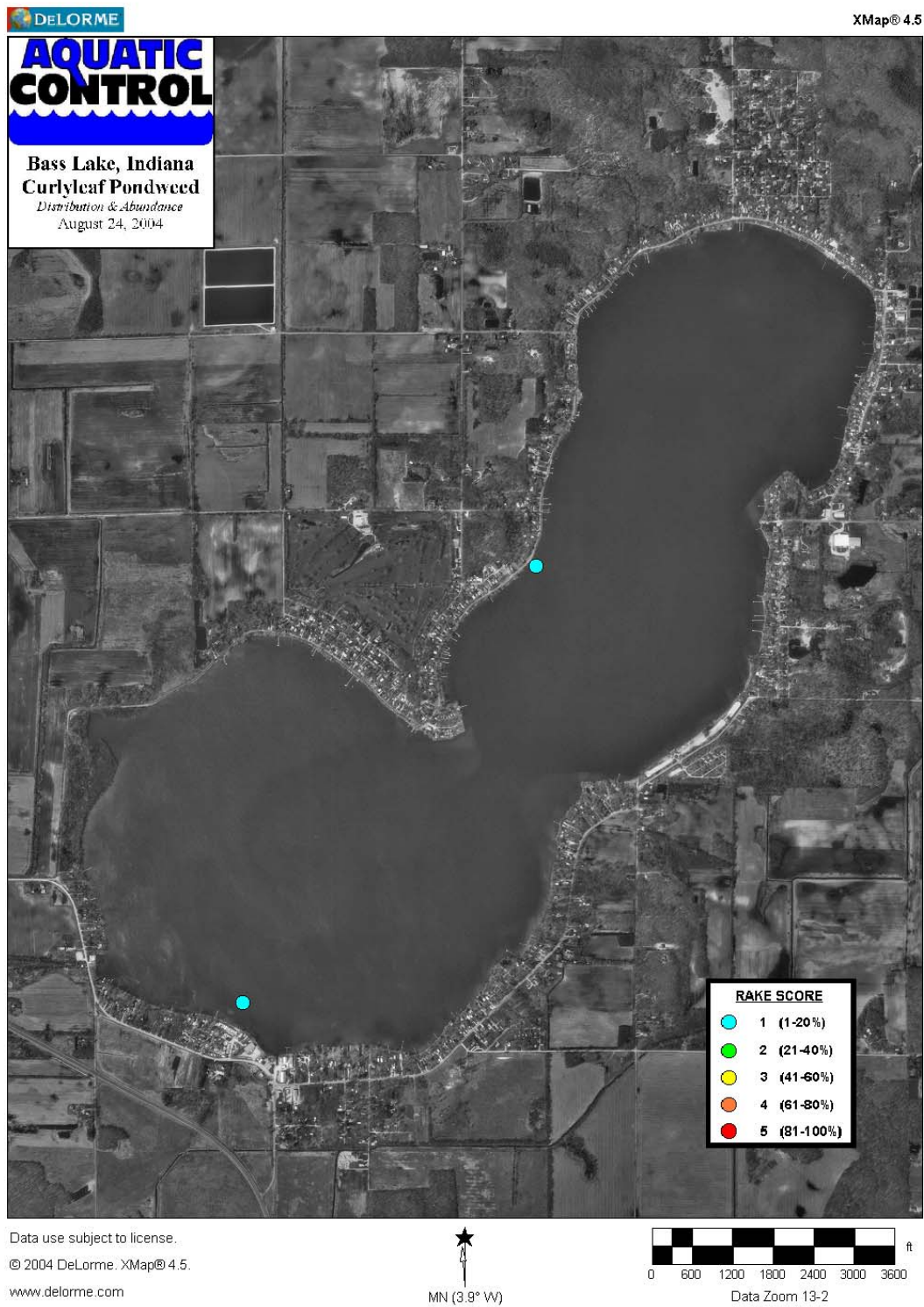


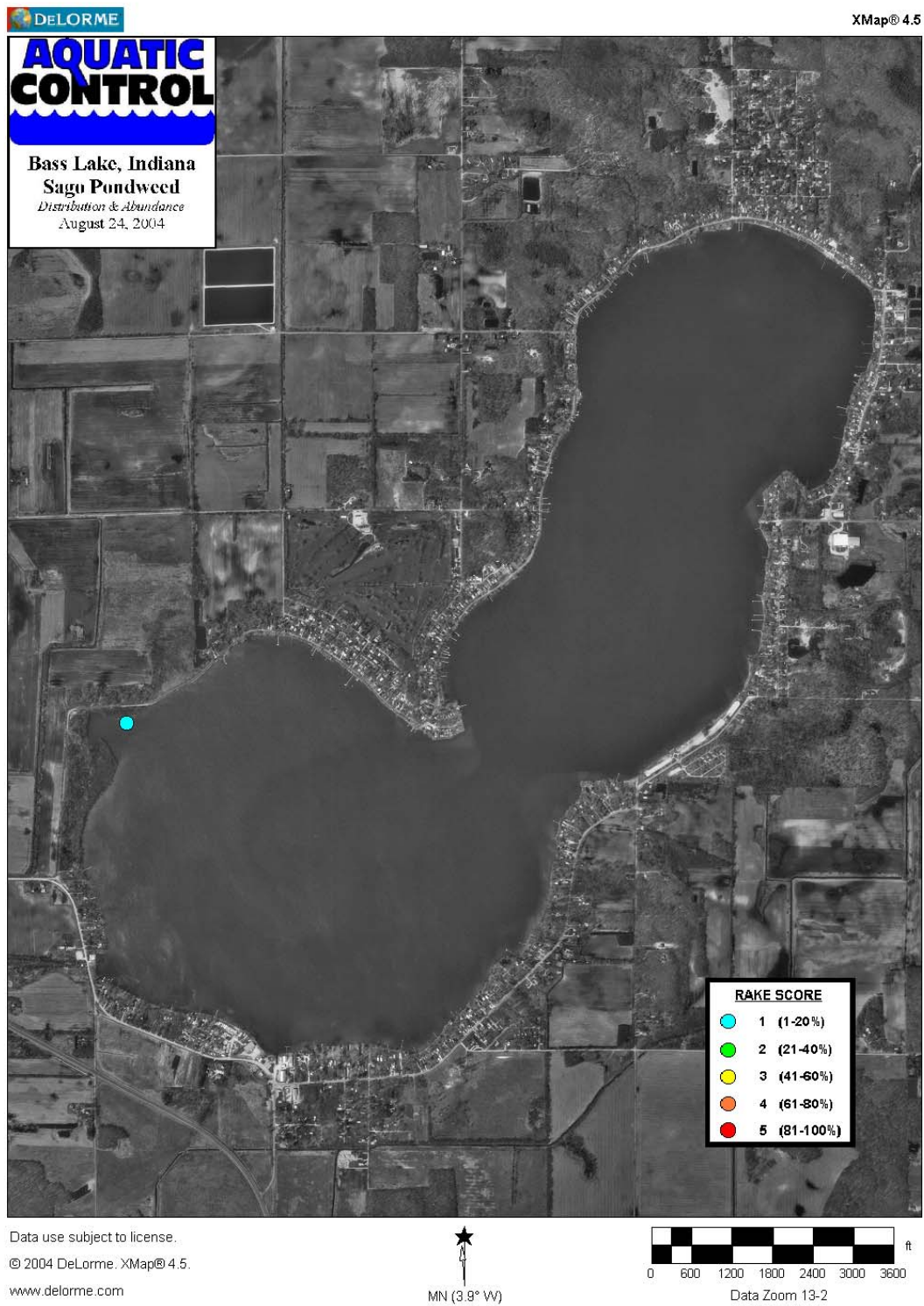


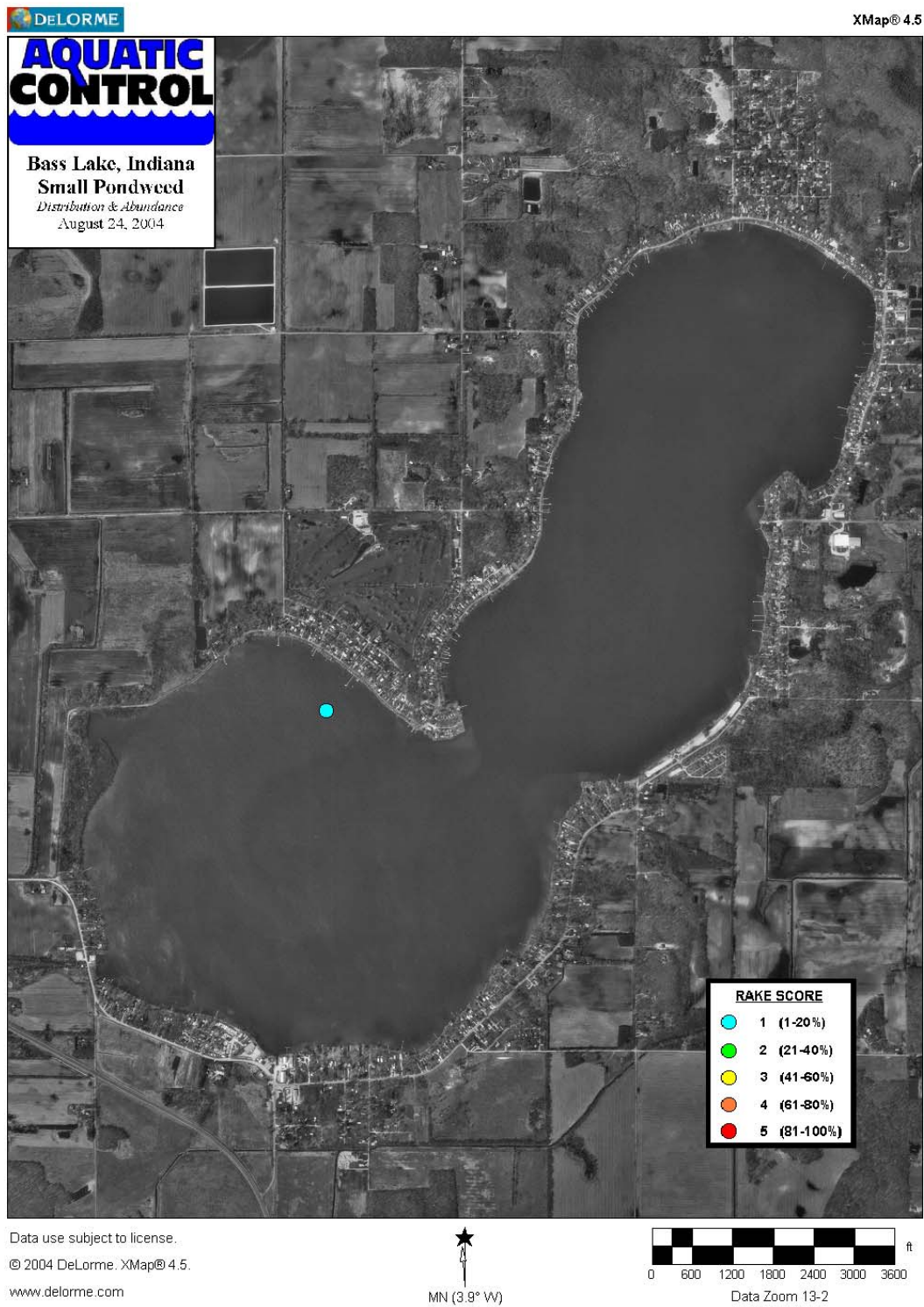












Appendix C. Tier II Data Sheets

Lake	Date	Latitude	Longitude	Design	Site	Depth	RAKE	MYS2	POCR3	CEDE4	CH7AR	POPE6	POPU7	ALGA	SpeNum	NatSpeNum	Species Codes	
Bass	8/24/04	41.21162	-86.610449	Random	1	3.0	1	1							1	0	BIBE	Bur marigold
Bass	8/24/04	41.21291	-86.609897	Random	2	2.0	1								1	1	CEDE4	Coontail
Bass	8/24/04	41.21437	-86.609329	Random	3	2.0	1								1	1	CH7AR	Chara
Bass	8/24/04	41.21566	-86.608614	Random	4	3.0	0								0	0	ELCA7	Elodea
Bass	8/24/04	41.21638	-86.607189	Random	5	5.0	1	1							2	1	LEMN	Duckweeds
Bass	8/24/04	41.21518	-86.607286	Random	6	4.0	5								1	1	MYHE	Broadleaf watermilfoil
Bass	8/24/04	41.21386	-86.608002	Random	7	4.0	2	1							2	1	MYSI	Northern watermilfoil
Bass	8/24/04	41.21265	-86.608088	Random	8	3.0	1								1	1	MYSP2	Eurasian watermilfoil
Bass	8/24/04	41.21122	-86.607984	Random	9	2.0	1								1	1	MYVE	Whorled watermilfoil
Bass	8/24/04	41.211	-86.606206	Random	10	4.0	1	1							2	1	NAFL	Slender naiad
Bass	8/24/04	41.21243	-86.60484	Random	11	4.0	5	1							2	1	NAGU	Southern watermilfoil
Bass	8/24/04	41.21365	-86.604182	Random	12	6.0	1	1							1	0	NAMA	Spiny naiad
Bass	8/24/04	41.21282	-86.60389	Random	13	5.0	1	1							1	0	NAMI	Brittle watermilfoil
Bass	8/24/04	41.21146	-86.603816	Random	14	4.0	1	1							2	1	NELU	American lotus
Bass	8/24/04	41.21029	-86.60372	Random	15	4.0	1	1							3	1	NI7TE	Nitella
Bass	8/24/04	41.20961	-86.602984	Random	16	3.0	2	1							2	1	NOA0VG	No aquatic vegetation
Bass	8/24/04	41.21081	-86.602186	Random	17	5.0	1	1							1	0	NULU	Yellow pond lily
Bass	8/24/04	41.21223	-86.601914	Random	18	5.0	1	1							1	0	NYTU	White water lily
Bass	8/24/04	41.21173	-86.600459	Random	19	5.0	1	1							1	0	POAM	Large-leaf pondweed
Bass	8/24/04	41.21051	-86.599902	Random	20	4.0	1	1							2	1	POCR3	Curly-leaf pondweed
Bass	8/24/04	41.20923	-86.599679	Random	21	2.0	1								1	1	POF03	Leafy pondweed
Bass	8/24/04	41.20967	-86.59856	Random	22	2.0	0								0	0	POGR8	Variable pondweed
Bass	8/24/04	41.21067	-86.598854	Random	23	4.0	3	1							2	1	POIL	Illinois pondweed
Bass	8/24/04	41.21117	-86.598909	Random	24	6.0	0								0	0	PONO2	American pondweed
Bass	8/24/04	41.21084	-86.597758	Random	25	5.0	1	1							2	1	POPE6	Sago pondweed
Bass	8/24/04	41.2106	-86.596091	Random	26	3.0	0								0	0	POPR5	White-stemmed pondweed
Bass	8/24/04	41.20983	-86.594615	Random	27	4.0	1	1							2	1	POPU7	Small pondweed
Bass	8/24/04	41.21089	-86.593188	Random	28	2.0	0								0	0	POR12	Richardson's pondweed
Bass	8/24/04	41.21215	-86.592514	Random	29	4.0	0								0	0	POZO	Flat-stemmed pondweed
Bass	8/24/04	41.21231	-86.590995	Random	30	3.0	1	1							2	1	UTMA	Common bladderwort
Bass	8/24/04	41.21343	-86.589777	Random	31	3.0	0								0	0	YAAM3	Wild celery, eel grass
Bass	8/24/04	41.21507	-86.588776	Random	32	6.0	0								0	0	WO7LF	Watermeal
Bass	8/24/04	41.21593	-86.588199	Random	33	4.0	0								0	0	ZAPA	Horned pondweed
Bass	8/24/04	41.21721	-86.588332	Random	34	3.0	0								0	0	ZODU	Water stargrass
Bass	8/24/04	41.21804	-86.587487	Random	35	2.0	0								0	0		
Bass	8/24/04	41.21942	-86.587535	Random	36	5.0	0								0	0		
Bass	8/24/04	41.21974	-86.586255	Random	37	2.0	0								0	0		
Bass	8/24/04	41.21988	-86.584768	Random	38	6.0	1	1							1	0		
Bass	8/24/04	41.2198	-86.583118	Random	39	4.0	0								0	0		
Bass	8/24/04	41.2207	-86.581532	Random	40	5.0	1	1							1	0		
Bass	8/24/04	41.22145	-86.579602	Random	41	2.0	0								0	0		
Bass	8/24/04	41.22245	-86.579484	Random	42	4.0	0								0	0		
Bass	8/24/04	41.22324	-86.577957	Random	43	4.0	0								0	0		
Bass	8/24/04	41.22469	-86.577584	Random	44	3.0	0								0	0		
Bass	8/24/04	41.22581	-86.577883	Random	45	5.0	0								0	0		
Bass	8/24/04	41.22674	-86.577027	Random	46	3.0	0								0	0		
Bass	8/24/04	41.22776	-86.576573	Random	47	3.0	0								0	0		
Bass	8/24/04	41.22899	-86.576892	Random	48	4.0	0								0	0		
Bass	8/24/04	41.22997	-86.57643	Random	49	1.0	0								0	0		
Bass	8/24/04	41.23085	-86.576131	Random	50	2.0	0								0	0		
Bass	8/24/04	41.23171	-86.575953	Random	51	4.0	0								0	0		
Bass	8/24/04	41.23223	-86.574573	Random	52	2.0	0								0	0		
Bass	8/24/04	41.23177	-86.573376	Random	53	5.0	5	5							1	0		
Bass	8/24/04	41.23221	-86.572438	Random	54	5.0	1	1							1	0		
Bass	8/24/04	41.23355	-86.572191	Random	55	4.0	0								0	0		
Bass	8/24/04	41.23475	-86.572151	Random	56	4.0	0								0	0		
Bass	8/24/04	41.23623	-86.571224	Random	57	3.0	0								0	0		
Bass	8/24/04	41.2375	-86.570469	Random	58	4.0	0								0	0		
Bass	8/24/04	41.23885	-86.570796	Random	59	5.0	0								0	0		
Bass	8/24/04	41.23967	-86.572155	Random	60	5.0	3	3							1	0		
Bass	8/24/04	41.24027	-86.573279	Random	61	5.0	0								0	0		
Bass	8/24/04	41.24082	-86.574475	Random	62	3.0	0								0	0		
Bass	8/24/04	41.24057	-86.575865	Random	63	4.0	0								0	0		
Bass	8/24/04	41.2412	-86.576601	Random	64	2.0	1								1	1		
Bass	8/24/04	41.24083	-86.57758	Random	65	3.0	0								0	0		
Bass	8/24/04	41.2405	-86.578824	Random	66	2.0	0								0	0		
Bass	8/24/04	41.23965	-86.579619	Random	67	4.0	0								0	0		
Bass	8/24/04	41.24012	-86.581081	Random	68	2.0	0								0	0		
Bass	8/24/04	41.23919	-86.582035	Random	69	2.0	0								0	0		
Bass	8/24/04	41.2381	-86.582726	Random	70	3.0	0								0	0		
Bass	8/24/04	41.23728	-86.582911	Random	71	4.0	0								0	0		
Bass	8/24/04	41.23794	-86.58403	Random	72	2.0	0								0	0		
Bass	8/24/04	41.23777	-86.584895	Random	73	2.0	0								0	0		
Bass	8/24/04	41.23674	-86.585407	Random	74	4.0	1	1							1	0		
Bass	8/24/04	41.23628	-86.584802	Random	75	6.0	4	4							1	0		
Bass	8/24/04	41.23537	-86.585335	Random	76	4.0	1	1							1	0		
Bass	8/24/04	41.23444	-86.585334	Random	77	4.0	1	1							1	0		
Bass	8/24/04	41.23369	-86.585655	Random	78	4.0	1	1							1	0		
Bass	8/24/04	41.23295	-86.586122	Random	79	5.0	1	1							1	0		
Bass	8/24/04	41.23221	-86.58682	Random	80	4.0	1	1							1	0		
Bass	8/24/04	41.23144	-86.586963	Random	81	4.0	3	3							1	0		
Bass	8/24/04	41.23042	-86.586963	Random	82	4.0	0								0	0		
Bass	8/24/04	41.22923	-86.587165	Random	83	4.0	0								0	0		
Bass	8/24/04	41.228	-86.587881	Random	84	3.0	1								1	0		
Bass	8/24/04	41.22703	-86.588807	Random	85	4.0	0								0	0		
Bass	8/24/04	41.22624	-86.589808	Random	86	4.0	0								0	0		
Bass	8/24/04	41.22575	-86.590832	Random	87	3.0	0								0	0		
Bass	8/24/04	41.22516	-86.590811	Random	88	6.0	1	1							1	0		
Bass	8/24/04	41.22464	-86.591553	Random	89	3.0	0								0	0		
Bass	8/24/04	41.22396	-86.592085	Random	90	3.0	0								0	0		
Bass	8/24/04	41.22321	-86.591838	Random	91	5.0	5	5							1	0		
Bass	8/24/04	41.22235	-86.591403	Random	92	5.0	0								0	0		

Lake	Date	Latitude	Longitude	Design	Site	Depth	RAKE	MYS2	POCR3	CEDE4	CH7AR	POPE6	POPU7	ALGA	SpeNum	NatSpeNum	Species Codes	
Bass	8/24/04	41.22143	-86.591312	Random	93	1.0	0								0	0	BIBE	Bur marigold
Bass	8/24/04	41.22067	-86.591293	Random	94	2.0	0								0	0	CEDE4	Coontail
Bass	8/24/04	41.22017	-86.591113	Random	95	2.0	0								0	0	CH7AR	Chara
Bass	8/24/04	41.21963	-86.591903	Random	96	2.0	0								0	0	ELCA7	Elodea
Bass	8/24/04	41.21886	-86.592949	Random	97	4.0	0								0	0	LEMN	Duckweeds
Bass	8/24/04	41.21923	-86.594192	Random	98	3.0	0								0	0	MYHE	Broadleaf watermilfoil
Bass	8/24/04	41.21992	-86.593968	Random	99	3.0	0								0	0	MYSI	Northern watermilfoil
Bass	8/24/04	41.22065	-86.593966	Random	100	2.0	1					1			1	1	MYS2	Eurasian watermilfoil
Bass	8/24/04	41.22062	-86.594951	Random	101	3.0	0								0	0	MYVE	Whorled watermilfoil
Bass	8/24/04	41.21988	-86.595326	Random	102	3.0	0								0	0	NAFL	Slender naiad
Bass	8/24/04	41.21925	-86.595817	Random	103	3.0	1	1							1	0	NAGU	Southern watermilfoil
Bass	8/24/04	41.21852	-86.595855	Random	104	3.0	0								0	0	NAMA	Spiny naiad
Bass	8/24/04	41.21803	-86.596723	Random	105	3.0	0								0	0	NAMI	Brittle watermilfoil
Bass	8/24/04	41.21704	-86.596934	Random	106	3.0	0								0	0	NELU	American lotus
Bass	8/24/04	41.21599	-86.597472	Random	107	3.0	0								0	0	NI?TE	Nitella
Bass	8/24/04	41.21484	-86.597933	Random	108	3.0	0								0	0	NOAQVG	No aquatic vegetation
Bass	8/24/04	41.21388	-86.598061	Random	109	5.0	0								0	0	NULU	Yellow pond lily
Bass	8/24/04	41.21468	-86.598829	Random	110	3.0	0								0	0	NYTU	White water lily
Bass	8/24/04	41.21676	-86.598343	Random	111	3.0	0								0	0	POAM	Large-leaf pondweed
Bass	8/24/04	41.21808	-86.597966	Random	112	3.0	0								0	0	POCR3	Curly-leaf pondweed
Bass	8/24/04	41.21964	-86.597339	Random	113	3.0	0								0	0	POF03	Leafy pondweed
Bass	8/24/04	41.22108	-86.59643	Random	114	3.0	0								0	0	POGR8	Variable pondweed
Bass	8/24/04	41.22218	-86.597513	Random	115	2.0	0								0	0	POIL	Illinois pondweed
Bass	8/24/04	41.22121	-86.59859	Random	116	4.0	1	1							1	0	PONO2	American pondweed
Bass	8/24/04	41.22031	-86.598848	Random	117	4.0	0								0	0	POPE6	Sago pondweed
Bass	8/24/04	41.21916	-86.599415	Random	118	3.0	0								0	0	POPR5	White-stemmed pondweed
Bass	8/24/04	41.21801	-86.600022	Random	119	3.0	0								0	0	POPU7	Small pondweed
Bass	8/24/04	41.2169	-86.600545	Random	120	3.0	0								0	0	POR12	Richardson's pondweed
Bass	8/24/04	41.21559	-86.600971	Random	121	4.0	1	1							1	0	POZO	Flat-stemmed pondweed
Bass	8/24/04	41.21448	-86.601482	Random	122	6.0	0								0	0	UTMA	Common bladderwort
Bass	8/24/04	41.21655	-86.601982	Random	123	3.0	0								0	0	VAAM3	Wild celery, eel grass
Bass	8/24/04	41.21795	-86.601761	Random	124	3.0	0								0	0	WO?LF	Watermeal
Bass	8/24/04	41.21923	-86.600984	Random	125	4.0	0								0	0	ZAPA	Horned pondweed
Bass	8/24/04	41.22082	-86.600113	Random	126	3.0	0								0	0	ZODU	Water stargrass
Bass	8/24/04	41.22216	-86.599219	Random	127	4.0	1	1					1		2	1		
Bass	8/24/04	41.22362	-86.600297	Random	128	3.0	1	1							1	0		
Bass	8/24/04	41.22259	-86.601553	Random	129	3.0	1	1				1			2	1		
Bass	8/24/04	41.22174	-86.602554	Random	130	4.0	0								0	0		
Bass	8/24/04	41.22054	-86.603505	Random	131	5.0	2	1				2			2	1		
Bass	8/24/04	41.21938	-86.603647	Random	132	5.0	3	1				3			2	1		
Bass	8/24/04	41.21831	-86.604104	Random	133	4.0	1					1			1	1		
Bass	8/24/04	41.21757	-86.604751	Random	134	4.0	0								0	0		
Bass	8/24/04	41.21907	-86.604596	Random	135	5.0	1	1				1			2	1		
Bass	8/24/04	41.22106	-86.604574	Random	136	3.0	0								0	0		
Bass	8/24/04	41.22227	-86.604221	Random	137	3.0	1	1				1			2	1		
Bass	8/24/04	41.22342	-86.603694	Random	138	2.0	1					1			1	1		
Bass	8/24/04	41.22353	-86.604758	Random	139	2.0	0								0	0		
Bass	8/24/04	41.22279	-86.605712	Random	140	2.0	0								0	0		
Bass	8/24/04	41.22182	-86.606815	Random	141	2.0	3	1				3			2	1		
Bass	8/24/04	41.22098	-86.607273	Random	142	3.0	0								0	0		
Bass	8/24/04	41.22002	-86.607121	Random	143	3.0	1	1				1			2	1		
Bass	8/24/04	41.21898	-86.606868	Random	144	4.0	2	1				2			2	1		
Bass	8/24/04	41.21803	-86.607207	Random	145	4.0	3	1				3			2	1		
Bass	8/24/04	41.2171	-86.608171	Random	146	3.0	1	1							1	0		
Bass	8/24/04	41.21555	-86.609685	Random	147	3.0	4					4			1	1		
Bass	8/24/04	41.21466	-86.61044	Random	148	3.0	2					2			1	1		
Bass	8/24/04	41.21667	-86.609971	Random	149	3.0	3					3			1	1		
Bass	8/24/04	41.21809	-86.608976	Random	150	4.0	1	1							1	0		
Bass	8/24/04	41.2195	-86.607841	Random	151	4.0	4	1				4			2	1		
Bass	8/24/04	41.2205	-86.60774	Random	152	2.0	1					1			1	1		
Bass	8/24/04	41.22167	-86.608043	Random	153	2.0	0								0	0		
Bass	8/24/04	41.22163	-86.609962	Random	154	1.0	1					1	1		2	2		
Bass	8/24/04	41.2205	-86.609779	Random	155	2.0	1					1			1	1		
Bass	8/24/04	41.21956	-86.6096	Random	156	2.0	1					1			1	1		
Bass	8/24/04	41.21868	-86.610105	Random	157	2.0	0								0	0		
Bass	8/24/04	41.21784	-86.610713	Random	158	2.0	0								0	0		
Bass	8/24/04	41.21614	-86.611048	Random	159	2.0	1	1							1	0		
Bass	8/24/04	41.21428	-86.611255	Random	160	2.0	1					1			1	1		
Bass	8/24/04	41.21359	-86.610865	Random	161	2.0	1	1				1			2	1		

